

A
NEW METHOD
OF
CHEMISTRY;

INCLUDING THE

History, Theory, and Practice
of the ART:

Translated from the ORIGINAL LATIN of

Dr. *BOERHAAVE*'s

ELEMENTA CHEMIÆ,

AS PUBLISHED BY HIMSELF.

To which are added,

NOTES; and an APPENDIX,

SHEWING

The NECESSITY and UTILITY of
Enlarging the Bounds of CHEMISTRY.

WITH SCULPTURES.

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CHEMISTRY

OF THE

MINISTRY

OF THE

NAVY

AND

ARMY

OF THE

UNITED STATES

OF AMERICA

BY

JOHN

W. B. HARRIS

OF THE

NAVY

AND

ARMY

2299

THE ELEMENTS OF CHEMISTRY.

PART III.

Containing the PROCESSES or OPERATIONS
of the ART.

PRELIMINARIES.

1. **N**OTHING has more disgusted the Intelligent, in turning over the writings of the Chemists, than those numerous suggested experiments, delivered under the title of *processes* (a). For these processes are found to be so many, and so different, that the life of a man is scarce sufficient to go through them all, nor any patience equal to the fatigue. But the greatest obstacle has been, that men do not perceive to what end all these labours tend. For were a philosopher to consult the artists themselves upon the subject, he would hardly receive a satisfactory answer. And after chemistry began to be taught in the universities, the writers of *chemical institutions* aimed at little more than delivering certain examples in a promiscuous manner. When, therefore, thirty years ago, at the request of my pupils, I undertook the teaching of chemistry; I seriously considered how to give publick examples of the chemical operations, in an elegant order, after the *Hippocratical* manner, so that nothing might be done without care and design.

2. The first thing to be here solicitously regarded, is to do nothing in vain; for what is more unnecessary, than to repeat ten times over, by other examples, what is sufficiently exhibited by one? When I have once shewn

(a) Chemical operations, or *processes*, are particular methods of changing the bodies described in the foregoing theory, by means of the instruments there enumerated; so as to render the changes observable to the senses.

Or more peculiarly, a chemical process is such an application of fire to any subject, as may effect a sensible change therein; yet leave the subject capable of being compared with what it was before.

Rules to be observed in conducting a course of chemical processes.

The Practice of CHEMISTRY.

how the fragrant water is procurable from baulm, there is no occasion nau-
sously to repeat the same things, by a fresh example in marjoram, rosemary,
and rue. Why should a person instructed to obtain the aromatic spirit of
citron-peel, be laboriously taught to do the same thing in numerous other
subjects (a)?

3. 'Tis however necessary that the learner be shewn a plain example of
every operation, which contains any thing singular, of service in the art,
and is not else exhibited by any other experiment: For the student in che-
mistry should at least understand the principal ways of procuring the useful
things. And it would be wrong in this art to leave any one unacquainted
with the useful methods of working. But to what purpose should a person
desirous of knowing the nature of salts in vegetables, see the method of
extracting them from their ashes, unless he also learns how distillation and
putrefaction may obtain, and produce them from certain plants?

4. Next, I considered, that the order to be observed in exhibiting these
processes, should be the order of the mathematicians, and the experiment
that was first made, be required to the artificial performance, or just under-
standing of the following (b). I also presumed there should be a relation
between them; so that the subsequent might proceed directly and imme-
diately from the antecedent: By which means, in a short time, with little
labour, and less expence, nearly the principal use of the whole art might
be learned; which use is highly excellent, as that whereby we understand
the powers of nature, and the instruments of health.

5. Lastly, in the conduct of these processes I would not have an eye
wholly to medicine; tho' I otherwise prefer this to other arts: no greater
fatality hath befallen either chemistry or medicine, than that weak opinion,
as if all chemical preparations were constantly proper instruments in phy-
sic. Whereas it is plain, that chemistry by no means administers to medi-
cine alone, but to universal physics (c). Let pharmacy enjoy the operations
of chemistry, but by no means claim them all to itself. Since therefore
the operations of chemistry are performed upon vegetables, animals and
minerals, we shall range our operations with regard to these three tribes of
bodies.

*To begin with
vegetables.*

6. We are obliged to begin with vegetables, because these every where
spontaneously offer themselves; and because most animals are composed of
vegetables taken as aliment, and converted into their own substance. And
tho' some animals may wholly feed upon others, yet at length they all derive
their nourishment and the matter of their bodies from vegetables; which
also undergo a chemical resolution with greater ease, on account of the greater
simplicity of their parts, and therefore may be the better understood. Mi-
nerals indeed are still more simple; but then their treatment requires more

(a) Perhaps by carefully observing this rule, a considerable number of the following pro-
cesses might be dropt as useless in this view.
See for instance process 6, 8, 10, 12, 16, 17,
19, 22, 24, 25, 26, 27, 28, 29, 30, 31, 41, 44,
46, 54, 57, 58, 59, 60, 61, 63, 69, 70, 71, 72,

80, 82, 83, 84, 85, &c. &c. which may inti-
mate a serviceable abridgment of the pure
elementary part of chemistry.

(b) This must not be understood in a strict
mathematical sense.

(c) See the uses of chemistry in the theory.

secret arts, less known instruments, and less obvious operations. Whence the law of method directs us to begin with vegetables.

7. To proceed the more regularly, we shall take for granted what is delivered in the theory upon the subject of vegetables (a): All which we are now proceeding to confirm by experiment.

8. A chemical operation we define the change of a body by the instruments of this art, to an end prescribed by the laws of the art.

9. The first operation to be performed in a course of chemistry should have these four conditions: *First*, It should be very easy, so as not to require any great physical labour; whereby a violent corporeal force is applied to the subject. *Secondly*, It should be simple, or not compounded of various concurrent operations; nor require a variety of instruments. *Thirdly*, The change it makes should not be very remote from the nature of the subject. *Fourthly*, The effect produced should rather consist in a separation of the parts, such as they were originally, than be changed by the operation: for as bodies, by this art, are resolved either into their natural parts, or parts acquired in the operation, it is plain that the first alone should here be obtained; so that by re-adjusting the same parts, we may be certain of producing the original subject again.

Conditions of the first operation.

10. By duly observing these four requisites in our first operation, we shall receive four great advantages. For, *first*, the artist will hence clearly perceive what those parts were, as they originally existed in the subject; and thence form a true judgment of its nature, and the disposition of its component parts. And without this procedure we might commit great errors, by imagining that the parts were such in the whole as they appear after the resolution. *Secondly*, We shall thus discover the nature of the remains, or what is left of the subject after it has been treated: for if only a gentle separation be made of the native parts, the remainder will appear but little altered. *Thirdly*, We shall hence be able to examine this remainder by a new operation: and thus by degrees every subject may be properly examined by all the art of chemistry. But under a different procedure, if a new operation was to be performed upon a subject greatly altered, little just knowledge could be acquired, and the science would rather be confounded than illustrated. In the *fourth* place, we shall hence obtain an exact knowledge both of the action employed in the experiment, and of the instruments employed to procure it; and what great advantages these are in chemistry is self-evident. I wish I could have found an author who had delivered his experiments in this method.

11. The laws of chemistry also require particular conditions in the subject of this primary operation: the first whereof is, that the part separated be the most simple of those afforded by any operation, so as to be uniform, like water. *Secondly*, that it be what enters the composition of other bodies, and not itself produced from them. *Thirdly*, that it be easily separable into those parts designed to be obtained from it: otherwise it might happen that a simple and tractable body might be very difficult to separate into its constituent parts; which is evidently the case in gold, quicksilver, and silver. The prin-

Conditions of the first subject.

(a) See the article vegetables in the theory.

The Practice of CHEMISTRY.

principal use of these conditions in our first subject is, that thus we may observe the natural order in our first production; and, at the same time, leave the remainder fit to have its other parts distinctly separated by new operations.

*Conditions of
the first in-
strument.*

12. Again, the instrument of this first operation also requires its conditions; and must in the first place be simple, that the changing power excited by its means may be easy to understand and apply; and also not foul the subject by the admixture of its own parts, which are often of a different nature.

13. Secondly, the action of this instrument must be such as is required in the subsequent operations; and therefore in this respect may be called universal, as its action must contribute in all the other operations; so that whilst other instruments act, this also must be concerned.

14. Thirdly, this instrument must occasion but little change in the subject; or no greater than may barely suffice for performing the first operation; otherwise the operation would be confused.

15. Fourthly, this instrument must not produce much disturbance in the different parts of the subject; for if these should be greatly disordered, or changed, by mixing confusedly among one another, the action of such an instrument would rather prejudice, than promote natural knowledge. When an instrument thus conditioned, applies its particular action to such a subject as above described, the artist will have an exact knowledge of the power of this primary action, and understand what will happen in the subsequent operation, so far as the efficacy of that first action is here concerned; and all these effects will therefore be clear, distinct, previously requisite to be known, and subservient to others. In particular, we shall hence evidently distinguish all the parts that naturally contributed to compose the subject.

16. It follows from the premises, that such a gentle action of fire, as is always present on our globe, being applied to the fluid and most moveable parts of a vegetable subject, so as to cause little alteration, but a gentle separation, will perform our first operation.

*The structure
of vegetables.*

17. All vegetables consist of solid and fluid parts: the solid parts are either vessels, or consistent gross parts made up of vessels. (1°.) The absorbing vessels of plants drink in the fluid moisture that touches them; the mouths of these vessels are spread over the whole surface of the plant, and all its parts, especially the root; they are dilated in a moist and hot air, and in the dewy and warm earth, but closed when it is cold and dry. Whence they open wider under ground, than in the air; and drink more in the summer, than in autumn, and the winter. Certain orifices also draw in the air like wind-pipes, and convey it deep into the body of the plant; as evidently appears in the blown *taraxacum*.

18. (2°.) There is another set of moving vessels in plants, which, being hollow, contain the juices drank in by the absorbent kind. These move from the surface through all the parts of the plant. This motion seems chiefly owing to the dilatation of heat, and contraction of cold: whence the vessels scarce ever rest long, but constantly contract and dilate by turns; the elastic fibres of the vessels thus continually propelling the juices. No valves have hitherto been here manifest to the senses; and the experiment of trees growing when inverted seems to shew there are none.

(3°.) Plants

(3^o.) Plants have also vessels that change the juices imbibed into others of different kinds and forms; for the juices received at the mouths of the vessels are very different from those which have passed thro' the vessels of the plant; and they gradually more assume the nature of each plant, the longer they have felt the force of more of its vessels; as we find confirmed by all kinds of experiments. There seem also to be certain sets of vessels proceeding from others, and constantly elaborating different kinds of juices in every plant.

(4^o.) Among these vessels, there are some that, rising laterally from these larger changing kind, thence receive a particular juice, which they again change by degrees into that of their own kind. Thus in the aloes-plant there are certain canals which carry a bitter juice, very different from those contained in the other vessels, and prepared in the same plant. Such particular vessels we also find in the greater celandine, where the eye may discern a yellow juice, made by secretion and farther change; as a milky one is found in the peculiar vessels of the spurge.

(5^o.) There are also peculiar receptacles in plants, where those particular juices are received, and long remain at rest; which were separated by the fourth kind of vessels, tho' these juices seem to be there farther elaborated and changed. Thus we plainly discover a fat substance collected, contained, and perfected in certain cavities; whilst it there passes through different, and often various kinds of forms; as we see in native oils, balsams, and rosins.

(6^o.) Plants also have excretory ducts which discharge the finer juices from their bodies; or else their vessels being burst by an encrease of quantity, thus let them escape. Every one knows that invisible exhalations breathe from plants; and that gums and rosins sweat from their broken cells. These several kinds of vessels contain each its peculiar fluid, distinguishable in every respect from all the rest; not only in consistence, acrimony, or softness, but also in colour, smell, taste, medicinal, nutrimental and poisonous properties: and the like diversity is found in the different parts of plants, even the remotest. We have a sweet liquor in the bottom cavity of the aloes-flower, tho' the juices in the other parts are bitter; and different kinds of juices are found in the root, flower, fruit, seed, leaves, bark and wood of vegetables. Again, the different native juices of plants are themselves composed of very different kinds of principles, which, by particular combinations of certain parts, constitute those juices; whence they again appear different, on account of the different proportions wherein these principles contribute to their composition. Hence we have juices that are aqueous, spirituous, saline, saponaceous, gummous, oleaginous, balsamic, resinous, gummo-resinous, and such as sweat in the form of tears, either from an incision made in their bark, or tender twigs; which thus distil a juice in the form of a limpid and tartish water; as we evidently see in the vine, the birch, the walnut, and many other trees.

19. It was necessary to premise thus much before we enter upon our first operation, in order to understand what sound, distinct, and just knowledge the art of chemistry may afford us in vegetables; and at the same time what confusion would proceed from an ill concerted operation.

The Practice of CHEMISTRY.

tion. We now proceed to draw some corollaries from what is above delivered.

Corollaries from the preceding doctrine of VEGETABLES.

Their natures,
with regard to
chemistry.

Coroll. 1.

20. **H**ENCE it appears that there is a great diversity in the juices of vegetables, to be observed with regard to chemistry; since some of their parts are readily moveable, and easily separable from the rest; sometimes even spontaneously; so that a gentle heat may almost obtain them pure; whilst others of their parts separate with greater difficulty, and require a stronger heat, and hence come to be obtained more mixed and confounded among one another: and the due consideration hereof is of great importance.

Coroll. 2.

21. Since so many different juices are found in the different parts of the same plant, there must of necessity be a great difference in the chemical operations, according to the different parts whereon they are performed. Thus, the pulp of *cassia fistularis*, chemically treated, must needs afford a very different production from the bark or cane. And thus the pith of the *sugarcane* affords a sweet or saccharine substance; and the other part of the plant an acid one. Let no one, therefore, inconsiderately say, he has chemically extracted this or that substance from a plant, without carefully relating what part of the plant he worked upon.

Coroll. 3.

22. There is another considerable diversity to be observed in respect of the colour of different vegetables, and their separate parts; as appears in apples, pears, cherries, strawberries, mulberries, and other fruit; and again, in a beautiful variety of leaves and flowers, which directs us to different ways of treatment. Thus, upon pricking the *spurge* or poppy, they weep an extremely white milk; but when bruised altogether, afford a dusky green coloured juice; whilst beet-root, on the other hand, yields an exceeding red juice when bruised, but when wounded one of a different colour.

Coroll. 4.

23. Again, we learn there is an extreme difference in the odours of the different parts of vegetables. Thus, no part of the *jacinth* is odoriferous but the flowers; whereas in the *citron*, the juice of the fruit, the rind, the leaf, the flower, the wood, have several and different scents. The different juices of the same plant seem each to obtain a different odour, according as the situation of their respective seats and vessels is farther removed from the pores of the absorbing surface. And this should be the more carefully observed, because the odours of plants greatly contribute to the distinguishing one plant from another, and are chiefly procured separate by the first operation in chemistry.

Coroll. 5.

24. We next observe, that different vegetables have also a variety of tastes; and to such degree, that among so many thousands of plants of different forms, there are scarce two to be said of the same taste; each of them having one peculiar to itself. Nor does this hold only of different plants, but also of the same individual, with respect to its different parts. And the same is to be understood, in the same sense, of colour and odour.

25. 'Tis

The Practice of CHEMISTRY.

7

25. 'Tis likewise manifest that the juices of the same plant are so different at different times, as scarce to appear of the same kind, either in respect of colour, taste or odour. And for particular virtues, no comparison can be made betwixt juices crude and mature. For from the spring, thro' the whole course of summer, to the end of autumn, vegetables are so different, at different times, as scarce to appear the same; at least they differ extremely in the four seasons. For, showers excite fragrant exhalations in plants, that in a dry time seemed faded; and to this head belong those differences that arise from the difference of the soil: thus the plants that grow in mountainous places differ extremely from those produced in a low wet soil.

Coroll. 6.

26. The preceding doctrine also informs us, that nearly all plants in their first rising and growth abound with thin, watry, saline juices; and at this time contain a large proportion of salt: but that, after having felt the summer's sun, they become less watry, spirituous and saline, and chiefly abound with oil: whence the same operation will necessarily procure quite different substances from the same plants at different seasons.

Coroll. 7.

27. Lastly, it is certain, that chemistry, tho' ever so exactly pursued, can scarce preserve the pure and perfect virtues of vegetables; as always mixing the parts first separated, along with those that succeed, and thus changing their extremely mutable nature, and introducing not only new forms, but properties. Chemical operations, therefore, are far from always separating the noble virtues naturally residing in some plants; but rather frequently alter them in a great degree, and sometimes turn them into the direct contraries; as appears to have been well understood by *Helmont* (a), when he expressly declares him "*happy, who could with safety and expedition cure diseases by means of crude simples*," this being the ancient method of cure, and recommended in *scripture*. For the *specific essence* is altered by fire: whence *extracts and magisteries* are frequently exhausted preparations: so great and lurking a thing is fire." And this admonition should be carefully remembered. On the other hand, it's certain that chemistry, by exquisite labour, does sometimes produce new bodies, that before had no existence in nature; and possessed of virtues otherwise unknown to nature; whence *art* by this means effects, what in the natural state of things were impossible, according to the just observation of *Helmont* in the same place.

Coroll. 8.

28. Thus much was necessary by way of introduction to our *processes upon vegetables*. If we should seem too tedious in our preparation, the caution we use must be an apology; for, one physical operation rightly performed, and free from error, will conduct to a thousand others that are to follow; but a single error in a *physical experiment* might occasion thousands.

29. We shall now proceed to our processes; and, always first examine by our senses the body we design to change, that it may be the better understood in its own nature, before it undergoes any alteration. In the next place, I will exactly describe the operation itself; whereby the subject, before examined, is to be treated; so that the causes which produce the effect may be understood. Thirdly, I will enumerate the effects produced in the subject by the operation.

The method to be observed in the processes.

ration. Fourthly, we will again examine the remainder, and compare it with what it was before; in order to learn the observable changes wrought upon it. Fifthly, I will endeavour to describe the several instruments employed in every operation. Sixthly, I will subjoin the physical corollaries, which spontaneously flow from the operation performed. Seventhly, I will add the medicinal virtues of the produce; with care to mention only such as may be verified by experience; avoiding all exaggeration: I will also declare the insignificance of many others, and mark the pernicious properties of some, which are often unjustly commended. And herein I judge I may be of service; as long experience, in chemical and medicinal affairs, has enabled me to perform this part; and as I have here no reason to deceive.

30. I will begin with a recent native vegetable that has hitherto undergone no change; and shall first draw from it all that would rise by the heat of the summer's sun; that is a very volatile and considerably simple water. As much as possible, I will perform all the experiments upon one, and the same vegetable; that we may thus precisely learn what effects different operations, conducted by the rules of art, and thus successively applied, will have upon the same plant. And after having shewn all the chemical ways of drawing a fragrant water from recent rosemary, I shall regularly proceed to shew how the salts, oils, and other things are to be obtained from the same plant; and this so long as possible: for thus we shall have a distinct and accurate knowledge of the chemical operations. Whereas, if we obtained the water from one plant, the salt from another, and oil from a third, the fermented spirit from a fourth, and the volatile salt, by putrefaction, from a fifth; we could neither rightly understand the analysis of the plant by the operations, nor the true action of the operations upon the plant; but all would appear confused. These preliminaries were necessary, before we came to the operations themselves; which we shall now begin.

PART

PART I.

Chemical Operations upon VEGETABLES.

PROCESS I.

The distilled water of rosemary, extracted in the form of vapour, by the heat of the summer's sun.

1. TAKE rosemary fresh gathered, in its perfection, with the morning dew upon it, and, 2. lay it lightly and unbruised upon the broad round plate within our little cylindrical furnace (a); the plate being first made clean, and fixed at the height of two or three inches (b). Then cover the furnace with its large conical still-head, and apply a glass receiver to the nose thereof. 3. In the fire-place of the furnace put a lighted coal (c), that does not smoke, and raise up an equable degree of heat, not exceeding 85 degrees on *Fahrenbeil's thermometer* (d); and let this heat be kept up so long as any liquor comes over. Then taking away the plant, put in fresh and proceed as before; continuing to do this successively till a sufficient quantity of the water be procured. 4. Let this distilled liquor be kept at rest, in a clean glass close stopped, for some days, in a cold place, whereby it will become limpid, and have the taste and odour of the plant.

The nature and use of this water.

1. In this water are contained, (1.) the liquor of dew, consisting of its own proper parts (e), which are difficultly separated from the plant; and cleave to it even in the drying. This dew, also, by sticking to the outside, receives the liquid parts of the plant, which being elaborated the day before, and exhaling in the night, are hereby detained; so that they concrete together into one external liquid, which is often viscid, as appears in wax, manna, honey, &c. (2.) This water also contains the fluid which exhales from

(a) Described, tab. xvii. fig. 2.

(b) Above the grate, suppose, or plate which supports the fire.

(c) This coal seems to be meant of *Dutch turf*, which, when once thoroughly ignited,

yields no gross smoke, but makes a lasting fuel, and will of itself entirely burn out, tho' buried in ashes.

(d) See the theory.

(e) See the theory.

the vessels of the rosemary, and which chiefly consists of simple water, as appears upon long standing in an open vessel; when the taste and odour vanishing, leave an insipid water behind. Another part of this water is that subtile, volatile substance, which gives the plant its peculiar taste and odour; for these the senses discover in it: but the remains of the process scarce afford any thing thereof. (3.) This same water seems also to contain seeds, or other little bodies; which in a certain time usually grow into a kind of thin whitish weed, suspended in the middle of the water; and daily encreasing, or spreading itself, becomes a mucilage, which did not appear at first.

2. I have kept these waters undisturbed in separate well-closed vessels, and observed, that in a year's time they began to appear thick; which thickness gradually encreased every year, till at length the whole liquor grew ropy or mucilaginous. Hence this water contains the elementary water, and presiding spirit of the plant, a spirit small in bulk but rich in virtue, and exhibiting the specific smell and taste of the subject. This water, therefore, in exhaling proves a vehicle to that spirit which contains in a small, subtile, extremely volatile, and thence easily separable substance, the particular virtue of the plant; leaving the remainder exhausted in this respect: and hence proceeds the medicinal virtue of these waters, which principally depends upon their native spirit. For this spirit, having a brisk mobility in most plants, affects the nerves, and raises the spirits in case of their depression. But besides this common principle of action, plants have another peculiarly appropriated to each, and of wonderful efficacy: this in the language of *Paracelsus* is called their appropriated essence.

3. The odoriferous scents both of lavender, and of baulm, agree in this; that they excite the languid nerves: but the smell of lavender, besides this, has another particular virtue, and so has baulm. From this virtue of plants proceed wonderful effects in the body; which can only be learnt from a faithful history of plants; where their virtues founded upon experience are delivered. This peculiar virtue has often a contrary effect to the common: the *Indian* hyacinth has an extremely fragrant odour; but excites strange spasms in hypochondriacal men, and hysterical women. Rue also diffuses a very strong scent, which cures the spasms occasioned by the former odour.

4. We must also observe, that human industry has discovered, that this fine vapour of plants is productive of those strange effects occasioned by vegetable concretes, as well in the way of evacuants, as alteratives; because if this alone be totally separated from medicinal or poisonous plants, the remainder, tho' without almost any sensible loss of weight, loses all that efficacy. Hence a chemist should be cautious and reserved in assigning the virtues of these waters, and learn for some time before he pronounces with certainty. From these observations we may say, that these waters will frequently cure fainting, and prove agreeable in the way of perfume; for nothing more directly proves more refreshing, and enlivening to the brain and spirits, than such a water of baulm or rue; each of them full of the respective spirit of the plants.

5. If the vessel be close stopped, and set in a cool place, these waters will retain their virtues for a year; but if negligently kept, or any crack should happen in the glass, their extremely volatile spirit secretly flies off, and leaves the water vapid. Our experiment also shews us, what it is which plants lose by being dried in the summer's sun; viz. the water, and the spirit we have been describing. Hence also we know the nature of that fluid, which first rises from plants in distillation; and what that matter properly is in plants, which gives their peculiar odour, viz. their presiding spirit. Lastly, we hence learn, in some measure, what those effluvia are, which, principally, in the summer season, and the open air, exhale from vegetables; for it is highly probable that these constant exhalations of plants, especially in the day time, have a great agreement in their peculiar nature with the liquor produced in our present process, tho' differing in this; that the exhalation is made from parts continually recruited by the root; whilst in our experiment those parts alone are collected, which are driven off from the plants, after being gathered, and no longer supplied with fresh nourishment. Whence the diligent and ingenious Dr. Hales observes in his *Vegetable Statics*, that the distillation of the juice received in glass-vessels, artificially applied to recent incisions of plants, in the summer season, is of a different kind (a) from common distillation.

6. Hence we may understand that the various, peculiar, and often surprising virtues of plants, may be widely diffused thro' the air, and carried to a vast distance by the winds. So that we must not presently account as fables what we find related in the history of plants, concerning the surprising effects of effluvia. The shade of the walnut gives the head-ach, and makes the body costive: The effluvia of the poppy procure sleep: The vapour of the yew tree is reputed mortal to those who sleep under it: and the smell of bean blossoms, if long continued, disorders the senses. The strong action of the sun upon plants certainly raises atmospheres of great efficacy, by means of the spirits it diffuses; and the motions of the winds carry them to a great distance. The dark shades of thick woods, where vapours are contracted, occasion various diseases, and often death to those who reside among them; as appears by melancholy examples in *America*, which abounds with poisonous trees. For this spirit of plants is a thing peculiar to each species, absolutely inimitable, nor producible by art. It has therefore virtues peculiar to itself, but such as are strangely agreeable to the human spirits. But because the spirits of some plants are very manifest to the senses, whilst those of others scarce affect our organs of smell and taste by any sensible action, the chemists have chiefly destined to this first process, those plants which are remarkable for their grateful odour: such as these of the following short catalogue, for example, taken from the *European* officinals, and a few of the *Indian*.

(a) See Dr. Hales's *Vegetable Statics*, pag. 50.

The Practice of CHEMISTRY.

Plants.

—Angelica.
 —Anise.
 —Basil.
 —Baulm.
 —Bays.
 —The Calamints.
 —Calamus aromaticus.
 —Camomile.
 —Caraway.
 —Cardamon.
 —Cassia aromatica.
 —Catmint.
 —Celeri.
 —Chervil.
 —Cinnamon.
 —Citron.
 —Clary.
 —Clove July flowers.
 —Coriander.
 —Cressies.
 —Cumin.
 —Dill.
 —Dittany.
 —Fennel.
 —Feverfew.
 —Galangal.
 —The Garlicks.
 —Heart-wort.
 —Hyssop.
 —Jasmin.
 —Lavender.
 —Leeks.
 —Lemmons.
 —Lily of the valley.
 —Lily, white.
 —Lovage.
 —Mace.
 —Marjoram.
 —Marum.
 —Masterwort.
 —Mastichina.
 —The Maudlin-tanseys.
 —Melilot.
 —Mint.
 —Motherwort.

Plants.

—Nutmeg.
 —The Onions.
 —Orange.
 —Origanum.
 —Philadelphus.
 —Polium.
 —Roses.
 —Saffron.
 —Sage.
 —Savory.
 —Scurvy-grafs.
 —The Southern-woods.
 —Spignel.
 —Tansey.
 —Tuberose.
 —Valerian.
 —Victorialis.
 —Violet.
 —Walnut.
 —Wild-thyme.

Trees.

—Bay.
 —Benjamin.
 —Box.
 —Cedar.
 —Citron.
 —Elder.
 —Fir.
 —Guaiacum.
 —Juniper.
 —Lemmon.
 —Lime.
 —Mastick.
 —Myrtle.
 —Orange.
 —Peach.
 —Pine.
 —Rose.
 —Sassafras.
 —Savin.
 —Storax.
 —Thuya, or Life-tree.
 —Walnut.

7. Several of these trees contain, in their different parts, an aromatic volatile matter, which may be obtained in this first operation; for sometimes their peculiar virtue resides in the root; as the camphorated balsam in the cinnamon root; or in the wood, as in the *Rhodium* wood; in the bark, as in cinnamon; in the husk, as in Walnuts; and frequently in the flowers, leaves, and seeds: Again, in the waters that distil from them, as in the walnut; in their balsams, gums, tears, and rosins, as in the balsamic trees. And so many things we learn from this first single experiment; more might be added, but perhaps more would be tedious.

PROCESS II.

The infusion and decoction from the remainder of the first process.

OUR second operation should be so directed, and performed, as perfectly to observe all the laws laid down by the first; for thus again we shall reap all the advantages that were there enumerated.

As therefore a dry heat of 85 degrees there performed its effect; it appears what action the fire and air in that degree have upon a plant. In this second we shall examine what fire and water, gradually raised from 85 degrees of heat to 212, or to the degree of ebullition may have; for water heated to 85 degrees throws off from a plant the water of our first process.

1. Take the remains of the rosemary in our first process, which have now lost their verdure, plumpness, and succulency, and are become brown, contracted, shrivelled, lighter, and almost without the natural smell, and of a taste somewhat foreign from that of rosemary. The whole is now brittle, which before was supple, soft, and viscous: All which may appear by comparing this remainder with the recent plant. Instead hereof we may take a plant gently dried, but not too long, in the open air of a shady place, or even what is fresh gathered; for this will make no considerable difference, because the water of our first process is always lost in the boiling.

2. To the subject, put into a clean vessel, pour pure clean rain water, heated from 85 degrees to the degree immediately under ebullition, viz. that of 212. Let the whole plant be well covered with the water; which must now stand together, in a close vessel, in this degree of constant heat for the space of half an hour, or more. Then pour off the liquor, which will now appear brown coloured, and have but little odour, being deprived of the taste of the rosemary found in the water of our first process. This is called the infusion of rosemary, and contains the virtue of the plant but little altered. If the water of the first process be mixed with it, it will advantageously contain the peculiar virtue of the plant for medicinal uses. And perhaps this is the best manner of conveying the medicinal virtues of herbs into the body, unless it be in the form of express juices.

3. If the plant be boiled for some minutes with water, the liquor then poured off is called a decoction, or apozem. If this be made in an open vessel, all the water of the first process is lost, besides much other matter,

The Practice of CHEMISTRY.

as we shall see hereafter (a). If the operation be here performed in a very tall chemical vessel, fitted with a still-head and a receiver, and the water that comes over be afterwards added to the decoction, the whole will then have the principal medicinal virtue of the plant. And if the operation be performed in *Papin's* digester, the decoction will then have the united virtues of the plant, without any loss of the spirit, or water of the first process. But the peculiar virtue of the plant is here changed, as appears both by the smell and taste, and in some degree by the effect; and it is extremely difficult in all these cases to preserve the odour, taste and colour perfect.

4. Upon the remains of the first decoction, pour boiling fresh water, make it constantly boil, then pour off the decoction, and carefully take off with a clean spoon all the froth that rises in the boiling, setting it apart in a clean vessel. This matter is unctuous, and, when gently dried, burns in the fire. Continue to pour on fresh water, pour off the decoction, and collect the froth, with care to avoid the admixture of any foreign matter, as soot, smoke, or the like; till the water at last poured on, comes off after a long continued boiling, as pure, tasteless, and colourless, as it was when put on; which will happen about the 20th repetition. After this it will be surprizing to observe the leaves of the rosemary remaining entire, turgid with water, of their original form and size; but having exchanged their green colour for a brown, and being sunk to the bottom of the water wherein they floated before.

5. The denser the plant is, and the more resinous, the more oily froth is thrown to its surface; and the less of that resinous, or oleaginous virtue communicated to the water, because not dissolved therein; and therefore for preparing a decoction of this kind, a long previous digestion, or the addition of a fixed alkaline salt, and, afterwards, or longer boiling are required; as hath been observed in making the decoction of *guaiacum* wood.

6. But even such resinous vegetables, if boiled when they are fresh, green, and succulent, their native saponaceous virtue still keeps their resin soluble, which running together, when dry becomes more difficult of solution. This has been observed by those, who, in *America*, have boiled the chips of green *guaiacum* in water, whereby they soon obtained a very penetrating liquor which cures the venereal disease; whilst the wood that has been long kept, being now less soluble in water; has a less effect.

7. Since, therefore, plants lose by boiling all that which goes off in the form of vapour with 212 degrees of heat; all those plants are unfit for this operation, whose virtue required is volatile with this degree of heat. But those, whose virtue resides in a more fixed matter than can be separated by this heat, are fit for decoction. Of this kind are the following acid, astringent, viscous, aromatic, emollient, cooling, nutritive, restorative, and saponaceous vegetables, and all viscid ones that are not too resinous.

—Acacia.
—Barberries.

—Brook-lime.
—Cinquefoil.

(a) See process 15. 29—30.

—Comfrey.	—Peniwinkle.
—Cranes-bill.	—Poppies.
—Currants.	—Purslain.
—Dandelion.	—Quinces.
—Dwarf-elder.	—Roses.
—Endive.	—Rhubarb.
—Fern.	—Scordium.
—Famitory.	—Shepherd's purse.
—Gentian.	—Stoes.
—Grass.	—Sorrel.
—Ground-ivy.	—Speedwell.
—Hellebore.	—Succory.
—Hypocistis.	—Sumach.
—St. John's wort.	—Tamarinds.
—Knot-grass.	—Tormentil.
—Myrtle.	—Water-lily.
—Nettles.	—Wood-forrel.
—Plantain.	—Wormwood.

To these may be added the fresh express'd and unfermented juice of summer-fruits.

8. Let it however be carefully observed, that I do not suppose that the peculiar virtue of a plant, which commonly resides in its presiding spirit, should always shew itself by some remarkable odour, fragrance, or aromatic taste: on the contrary it may happen, that the spirit shall be extremely active without remarkably affecting the senses; as appears in the black hellebore root, the *cicuta aquatica Gesneri*, the *solanum maniacum*, &c. whence all these particulars are very cautiously to be considered before any general rule is laid down.

The nature, virtues, and effects of these infusions and decoctions.

1. These preparations may pass through the lacteal and mesenteric vessels, and mix with the venous blood of the *vena cava*, and thus by the vital motion be mixed with the humours of the body, received into all the larger kinds of vessels, reach to the viscera, and all the other parts of the body; for they are saponaceous, penetrating, and miscible with every humour.

2. And here they may act by their own peculiar force remaining in the liquor of the infusion or decoction; which faculty of action is then greatly increased by the force of the vital motion, and thus produces sudden effects.

3. But they want that efficacy which remains in the water of our first process, tho' the infusion contains more of it than the decoction. But in the decoction, however, this want is supplied by a greater efficacy, which the boiling heat communicates thereto, by enabling it to dissolve, and intimately mix the virtues of the plant with the water by long boiling. Whence, if the operation were performed in a still with its alembic head, and the exhaling water returned to the remaining decoctions, then these decoctions would

would become exceeding rich in the virtues of the plant; as will evidently appear in the *fifteenth process*: for such a liquor will contain nearly all the powers of the subject.

4. It must be well considered, that the medicinal virtue of infusions and decoctions depends as much upon the efficacy and quantity of the hot water received, as upon the virtue of the plant. This is known to physicians. Were it not an error, in condemning the use of tea, to attribute the mischief wholly to the leaves, when the larger part is hot water: and again, when we attribute the virtue of enlivening the spirits to the drinking of tea, is the diluting virtue of hot water to be omitted?

5. Hence may be understood the pharmaceutical law, method, instrument, subject, and effect of preparing infusions and apozems; as also the efficacy of the hottest water upon the solids of a plant. Who, but an eye-witness, would believe that a two days boiling should not, with all its force, destroy the tender leaves of rosemary? nay, what is more, tho' the tenderest flower were to be ever so long boiled in water, yet, upon taking it out, and carefully examining it by the eye, or even with a microscope, it will be found perfectly unaltered. I have made the experiment, and continued the boiling for a very long time, yet at length found all the hairs, little risings, tubercles, and fibres the same, without any difference. From hence physicians may understand, why the smallest vessels of our bodies are not dissolved by the hot juices they carry. Some may suspect, that the mechanical triture, which the force of the pulsation makes against the sides of the canals, should rather break them, than the power of heat or moisture; but the last elements of our solids are not so much saline, saponaceous, or oily, as merely terrestrial, and joined together by a certain cement. For what we have above said, concerning the force of boiling water upon vegetables, is also true of the parts of animals, treated in the same manner.

6. If the leaves remaining after this operation be dried, they become shrunk, and small; but if again steeped in hot water, they exactly recover their former size and figure.

7. But some of the peculiar virtues of plants are altered by the boiling. *Arum* grows milder by decoction; the crude juice or infusion of *asarabacca* proves strongly emetic; but this virtue, by long continued decoction, is changed to another, that is diuretic and aperient.

PROCESS III.

The sapa, defrutum, extract, rob and jelly, from the produce of the second process.

AFTER having examined the infusions and decoctions of our second process; the law of method requires, first, to try what will remain upon evaporating the water employed in those preparations; for thus that part of the plant will gradually appear which gave it its virtues, and thence may

may also be chemically known the nature of all those parts of vegetables, which are soluble in hot water, and may be extracted by its means.

1. Let the infusions or decoctions of our second process stand at rest for some hours, in a cool quiet place, and in a clean vessel covered on the top, that they may thus deposite their gravelly earth, and other gross or ponderous feculencies, not belonging to the plant itself. They may also be passed through a strainer till they become clear; but then the gummy, somewhat resinous and viscous parts belonging to the plant will be also separated; and thus indeed they may be obtained the purer for medicinal use; tho' they lose something requisite in their chemical examination. The apothecaries, requiring them extremely pure, have another method. They intimately mix the recent white of eggs with their decoctions, by long whisking them together, then boil the whole, whereby the white of the eggs, now hardened by the boiling, concretes together in the decoction, and at the same time entangles the grosser matter with itself: so that now the liquor being strained, leaves much gross feculency behind, and passes sufficiently clear. And these are the three ways of purifying decoctions, viz. by rest, by the strainer, and by white of eggs; the former whereof is suited to chemical examinations.

2. Let the liquors, thus purified, be put into a clean cylindrical open vessel, or one that widens upwards, and set over a clear fire, and there kept nearly in a state of boiling; so as to exhale, and acquire the consistence of thick honey; with care to avoid boiling strongly, for fear of exhaling off what should be left behind, and to prevent burning at the last; which would destroy the virtue.

3. The same preparations may be likewise obtained from the fresh express'd juices of plants; particularly the juices of summer fruits, and succulent roots, such as liquorice. These subjects being taken ripe, recent, and perfect, and being first cleansed, and bruised, the juice is to be express'd, diluted with water, and purified by rest, and the strainer; and then to be exhaled in the manner above-mentioned, to the natural consistence they had upon expression. The juice thus fresh express'd, or reduced to its natural consistence, after having been diluted and strained, may be called *must*: and when this *must* is boiled to an half, so as to be long kept sound, and possessed of its natural taste, it has been called *sapa*; but if boiled till only a third part remained, it has been called *defrutum*, which may be preserved still longer without losing its former nature. But when the liquor is at first extremely well purified, and again gently boiled till a drop let fall on a cold plate grows firm and transparent, almost like ice, it is called *jelly*. If it have the consistence of thin honey, it is called a *syrup*; if it be somewhat thicker, a *rob*. All these preparations are indifferently called *extracts*, which are therefore termed either liquid, thick, or even, sometimes solid.

The nature, virtues, and uses of the preceding preparations.

1. All the foregoing preparations may be dissolved in warm water, and then they resemble the decoctions of the second process; tho' they have by their boiling lost some of their former virtue.

VOL. II.

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2. They

2. They may be long kept without spoiling, even for years.
3. They retain much of the taste of the vegetable, tho' the volatile part is lost in the preparation.
4. They long preserve the virtues of plants entire, and free from the incumbrance of their vascular parts: such virtues we mean as remained in them after this preparation; for so much they long preserve from corruption.
5. Hence it appears what it is that plants lose by long keeping, and corrupting with age; for hot water extracts nothing from the plants so corrupted: all the juices being gradually washed out of such dead plants, which are reciprocally penetrated, dissolved, agitated, and dried by the moisture of the air, dew, rain, and heat of the sun; whence they become effete and dry skeletons of plants. The worm also consumes the juices of vegetables, so as at length to leave nothing but a mere solid, insoluble, sluggish, and terrestrial part.
6. They who make long voyages, may receive great advantage from the productions of this process. Sailors are subject to diseases from the use of meats much salted, dried and smoked; which diseases are remedied by the juices of fruits: and thus by dissolving the jelly of oranges, barberries, cherries, quinces, lemons, *China* oranges, currants, grapes, rob of elder, rob of juniper, &c. in water; they may have a present remedy. These preparations are also easily recruited when they touch at any fruit-island; and perhaps nothing would more conduce to the health of the *British* and *Dutch* sailors, than a due provision of this kind.
7. It must, however, be observed, that the juices abounding with salt are difficultly preserved, when thus thickened, from running in the air; salt being attractive of water. The method, therefore, is to keep them in well stopped glasses. And, lastly, those vegetable subjects are unfit for this operation, whose medicinal virtue is volatile.

P R O C E S S I V.

The calcination of the insipid inodorous plant, remaining after the second process, but still retaining its native figure; or its reduction to insipid ashes, of the same form with the plant.

AFTER having learnt what effects hot air and boiling water have upon plants, and what may be drawn from them by their means; we must next enquire, what effect the open force of fire may have upon the remains of our second process.

1. Take the vegetable subject remaining after the action of our second process, under the conditions there explained; (a) lay it upon a clean open iron vessel or ladle, place this ladle upon a clear fire that yields no smoke to disturb the operation; this being a particular that requires caution, because something saline might easily insinuate. This fire should be continued

(a) See process 2. of the nature, virtues, &c. §. 5, 6.

so fierce, and so long, till thro' various degrees, all appears wholly ignited. First, a smoke ascends and grows gradually stronger; turning at length black, and as it were pitchy. Secondly, during all this time, there is a strong smell of burning, which encreases as the smoke encreases. Thirdly, when the pitchy smoke and fetid vapour at once break into open flame, the smoke ceases, and the scent also greatly diminishes. Fourthly, the plant becomes totally black before the flame arises, nor does it burn before; but as soon as it becomes perfectly black, it directly takes flame. Fifthly, when the flame ceases, the leaves almost lose their blackness, and become white, but where any thing black remains amongst them, live sparks are seen; but no flame in the leaves; and this sparkling continues so long as the least blackness remains. But when the preceding flame, and the subsequent sparkling have consumed all the blackness, there remains a white ash, which sparkles no longer with any shew of fire. Sixthly, it is here very remarkable, that after all this violence of fire and flame, the original form of the rosemary should remain in these white ashes; so that if such a leaf be examined, as it lies, by the microscope, it not only exhibits the natural form of the plant; but even the down, the hairs, the risings, the fibres, and the cavities appear as manifest, as if the plant were entire; but if moved, tho' but by the breath or a gentle touch, these leaves become dust, and have lost all their cohesive power.

2. The ashes, thus carefully prepared, are perfectly insipid and scentless; put them now into clear rain water in a clean glass; boil them together, depurate the liquor, first by standing, and then by the strainer, and it will become limpid, inodorous, and entirely free from any thing saline, tho' tasting somewhat like a decoction of lime. If this liquor be exhaled in a clean vessel, it leaves no fixed salt behind, but only a little matter like lime. The remaining ashes are white, free from salt, and fixed in all degrees of fire; being merely terrestrial, without water, spirit, oil or salt. These ashes made into a paste with water, formed into little cups and dried, make the best kind of *tests*, as enduring the strongest fire. And all these particulars hold, whatever plant be used; so that the process is universal.

The use of this process.

1. Hence we learn, that water boiling with as great a degree of heat as it can receive, may extract from a plant all that is saline, whether it be volatile, or fixed.

2. That no force of boiling, in any quantity of water, is able to separate the fixed oil, which here manifests itself to remain behind; first, by the gross odorous, bitter, black smoke, that presently turned into flame. Secondly, by the black colour of the plant, beginning to burn by the force of the fire; for this black colour constituted a coal, where the oil burnt by the fire grows black, rarifies, extends itself more upon the earth of the plant, and disposes it easily to catch flame or fire. Thirdly, by the open flame rising from, and supported by this black unctuous matter, and entirely consuming this black oil. And fourthly, by the sparks of fire which remained in this coal, after

the flame ceased, so long as any black unctuous matter was left; but when this was consumed, no more sparkling could be excited by art.

3. We hence see, that this fixed oil cannot be separated from a vegetable, without the help of an open fire, and a free air; for if our ladle were to be filled with the remains of the second process, and covered with an iron plate, and then committed to a violent fire, the plant would long remain black, brittle, and bitter, as a coal, but never become white. But, upon removal of the cover, it will burst into open flame, and fall down into white ashes.

4. That this oil joins the terrestrial elements of a plant together, so as to make them cohere, but, when taken away, to leave them incoherent. For although the boiling water extracted so much salt and oil in our second process, yet the remains held together as much as before; but when this last oil was separated, there remained not the least cohesion, but the terrestrial parts spontaneously fell asunder. Whence the oil extracted from plants by water, is not that cement which gives them their cohesion, but this last or more fixed oil. Possibly, therefore, this last kind of consolidating oil may be the same in all vegetables, whilst that dissolved in the decoction is peculiar to each species. Whence we have three kinds of oil in vegetables; viz. 1. An oily froth; 2. The oil dissolved in the decoction; and, 3. This consolidating oil, separable only by a naked fire.

5. The other part remaining in vegetables after decoction is a mere subtile earth, that neither coheres together, nor suffers any change in the fire; being the same in all plants, and in every respect like the white ashes of calcined animal substances. And this earth it is, which gives an unalterable basis to all vegetables and animals; for the assay-masters make their tests from these earths, both of plants and animals.

6. If water be poured to the ashes thus dissolved, they recover some degree of tenacity, as we see in the making of tests; but if mixed up with a proper quantity of oil, they cohere more strongly; so that earth and oil give solidity to plants.

7. That all the medicinal, nutrimental, and poisonous virtues of plants entirely reside in that part which may be extracted from them by water; neither the connecting oil, when joined with the earth, nor the earth alone, having any thing peculiar.

8. Therefore the longer, and the more any plants are dried, the more they lose of these virtues. So that if a plant remain long exposed to the common open air, there will at length be nothing of it left besides an indolent earth.

9. And hence it is, that plants remain unhurt by the moist air, dew, rain, and the action of the sun, whilst fed by the earth; and that the utmost force of boiling water cannot destroy the tenderest flower, as being unable to separate this ultimate oil from the elementary earth. The basis therefore of plants and animals is earth alone.

10. Hence we see that salt does not reside in the ultimate solid texture of plants, and therefore is in vain sought therein. And all these particulars hold also of the ultimate solids of animals.

11. The free admission of air disposes fire to separate this ultimate oil from the earth; nor could fire alone, without air, have this effect even on the tenderest plant.

PROCESS V.

The preparations of the third process afford saline ashes by calcination.

AFTER having seen the action of the naked fire on the remainder of the plant of our second process, we are likewise to see its effect upon the infusions, decoctions, and extracts prepared in the third process; that so by comparing the effects of the fourth and this fifth process, we may learn the force and action of fire upon plants.

1. Let the extracts, prepared in the third process, be put into a clean iron ladle, set over a gentle clear fire, and by degrees be made perfectly dry: when they will appear black, slimy, and tenacious. When brought to this state, and urged with a stronger fire, they by degrees emit more fume, and, at length, when the ladle begins to ignite, smell empyreumatical, afford a black, bitter, and gross vapour, then take flame; soon after, the matter sparkles in the parts where it still remains black, and at last falls into a pale, yellowish ash, tho' before it was exceeding black.

2. These ashes, being in the same vessel long continued on the fire, grow whitish, remain fixed, and become inodorous; but of a saline, sharp, lixivious, and somewhat urinous taste; and, when tasted, leave a little earth upon the tongue. If dissolved in fair water, filtered, inspissated and dried, they afford a yellowish salt, inclining to white, of a sharp, fiery, lixivious, and somewhat urinous taste; but the degree of sharpness, and quantity of this salt differ according to the nature of the plant; and again, according to the strength of the fire employed.

The use.

1. Boiling water, therefore, dissolves the oil and salt of plants, and the earth intimately adhering in them both.

2. But this oil being mixed with the salt of the plant, into a kind of soap, may in the plant be perfectly mixed with water; whence the native juices of vegetables are understood to be saponaceous.

3. When the water is separated from this soap, its oil, which is inflammable, being now more urged by the heat, grows black, rarifies, and spreads over the surface of the salt; kindles into flame, consumes, and leaves the salt deprived of its oil. Hence, the matter is a true vegetable coal, consisting of water, salt, and oil.

4. This oil gave the colour to the extract, and a thick black fetid vapour, and a black colour in the fire, and all the remaining odour; this alone being combustible.

5. Upon

The Practice of CHEMISTRY.

5. Upon mixing the water of the first process, the infusion of the second, and the salt of the fifth, a compound, of considerable medicinal virtue, may be obtained.

6. When sharp, pungent, alkaline vegetables, of a volatile and fiery nature, discoverable by their forcing tears from the eyes, are made the subjects of this process, all the same particulars happen; only scarce any salt remains in the ashes, as being here volatile. We have instances hereof in onions, scurvy-grass, horse-radish, mustard, &c.

PROCESS VI.

A recent plant, or the remains of the first process, afford saline ashes by calcination.

1. **P**UT a quantity of recent rosemary, or the remains of the first process, into a clean iron ladle; set it over a clear fire, which is to be slowly encreased by small degrees; and here, (1.) There will rise a strong-smelling, watry, colourless, and somewhat transparent fume of rosemary, which continues till the plant begins to turn black. (2.) When the plant is become blackish, there rises a grosser, blacker, stronger scented, and empyreumatical fume; at which time the whole appears black like a coal, which now immediately takes flame, burns and ceases to smoke; then glows, sparkles, and leaves a white ash, retaining the natural form of the plant, as in the fourth process; from which the present hitherto differs in no respect. (3.) Hence the oil of a plant thus acted on by the fire is always black; whether it be thrown off and agitated in the air, so as to form a pitchy smoke; whether it be extended and burnt upon the salt, earth, or both together; or whether this oily black smoke, ignited by the fire, or rolled rapidly round, constitutes flame; from whence escaping, it still makes a black soot; and shews, that bright flame is no more than black oil resolved into fire. But as soon as this unctuous matter of the plant, which at first turns black in the fire, is entirely consumed, neither flame nor fiery sparks can be then any way produced; and therefore in this state the whole remainder or ashes of all plants appear constantly white. (4.) The ashes thus procured from the tender part of a plant, exactly retain the natural figure thereof, after having suffered all this violence of the fire; but when some very gross part of a vegetable is burnt, the whole grows perfectly black, and becomes a coal; that part whereof which lyes exposed to the air, being alone consumed at first by the shining fire, affords white loose ashes; after which the black layer lying under the ashes, is again consumed by the loose fire, and thus it proceeds successively, whence the figure of the matter is at length destroyed by burning; because the force of the internal fuel throws off the external parts, now turned into ashes, from the center outwards, which does not happen in thinner subjects. (5.) When these ashes are tasted, they are found sharp, fiery, lixivious, and urinous upon the tongue: when diluted with fair water, the

the filtered liquor by evaporation affords a salt as in the fifth process, tho' in a much less quantity. The part remaining in the filter is a mere earth, in a large proportion, as in the fourth process.

The use.

1. Hence it appears, that water assisted by the force of fire, dissolves only the juices of vegetables, without touching the solids.
2. That fire by itself, has scarce a greater efficacy, and, when used alone, extracts less from vegetables; as thus leaving their salt behind.
3. That water even extracts much of what is inflammable, which when not extracted adds to the combustible matter of vegetables.
4. That the saline part of certain vegetables is not rendered volatile by this fire, tho' the oil is, which adheres thereto.
5. That the oil and salt, naturally mixt in plants, are together soluble in water, so as to remain united, tho' separable by fire.
6. Therefore the juices of plants and animals in a healthy state contain a native soap; but if either the oil or the salt be separate, then their juices become morbid; which Hippocrates observed when he said, *things wholesome when mixt, may be hurtful when separate.*
7. The elementary difference of plants therefore consists in their juices alone; the earth and cementing oil being common in them all.

PROCESS VII.

The native salt of plants from their fresh express'd juice, by an example in sorrel.

FROM the foregoing processes we learn the action of the air, water, and fire, upon the solid and fluid parts of plants; what may be produced from them by means thereof; into what they are separable by these instruments; and that a fixed salt may be extracted from vegetables. But we are now more carefully to examine under what peculiar form the salt of plants resides in their natural juices; of what different principles it consists; and what are its properties; in order to distinguish betwixt the vegetable salts produced by nature in the vegetable kingdom, and those produced by chemical fires; which is a matter of importance. For nothing has occasioned grosser errors than the common opinion among the chemists, that salts exist in plants such as they are thence produced by a violent fire. It is no safe conclusion that a salt was contained in a plant, because it was thence extracted, by the means of fire; the caution required in chemistry will teach us to argue thus; such a salt was extracted from such a plant, with such a degree of fire; therefore there was in that plant a native matter, which when treated in this manner, afforded this salt; and that a fat and oily inflammable matter, intimately united with one that is merely saline, will afford a native salt.

∴ (1.) Take

(1.) Take a large quantity of broad-leaved garden sorrel, in the prime of its growth, a little before it flowers; let it be gathered early in the morning, and well washed from its sand in fair water; cut it, bruise it, commit it to a clean linen bag, and squeeze out all the juice, in a strong press. This juice will be very acid, green, and thick as *milk*. (2.) Dilute it with six times its quantity of pure rain water, that it may the better pass the strainer; now filter it thro' a conical linen bag, returning it so often, till at length it becomes pure, thin, and limpid; at which time it will be gratefully acid. (3.) Put the liquor, so purified, into wide glass-vessels, and inspissate it by a very gentle boiling, in a place free from dust, and over a clear fire, till the remaining matter become almost as thick as recent cream, and strongly acid. (4.) Pour this thick liquor into a clean urinal-glass, which it may fill up to within its neck, then gently pour on the top a little pure oil-olive, to the height of about the tenth of an inch; and thus let it stand at rest for eight months, upon the floor of a cellar. By this means, the oil preventing fermentation, putrefaction, and ropiness, a salt will be produced resembling tartar; which nearly approaches to the natural salt of vegetables. (5.) The liquor, therefore, being now poured off, let the salt be a little washed by the quick and sudden affusion of cold water, to cleanse it of its adhering slimy feculencies; then gently dry it, and it will be the native salt of the plant. (6.) This salt I never found alkaline, whatever was the herb that afforded it. It was manifestly in the juice, but separated itself therefrom, and concreted into saline glebes. Upon comparing this salt with that produced by calcination in the fifth and sixth process, there is a great difference found in the colour, taste, figure, and every physical and medicinal effect. The present salt resembles the juice of the plant; whilst the other is a creature of the fire, that did not pre-exist the same in the juice of the plant.

2. This process may be performed upon the juice of any other succulent vegetable; but a different salt will be always produced according to the different nature of the plant employed. If the juices were either manifestly and purely acid, or acid with some degree of austerity, the salt will resemble the tartar of acid austere wines. If a perfectly succulent plant were chose, and neither acid or oily, as many medicinal ones are, the salt will be of another particular nature, perhaps resembling nitre. Such a salt is afforded by brook-lime, endive, fumatory, dwarf-elder, grass, knot-grass, plantain, self-heal, succory, water-creffes, water-lilies, &c. Whence the juices of these plants are greatly medicinal, as abounding with this kind of nitrous salt, so as to open inveterate obstructions, resolve the black bilious juice, and cure chronical diseases. But when the viscous juices of vegetables are used in this process, as those of purslain, comfrey, or the like, their salt cannot be obtained, without a previous fermentation to dissolve their tenacity. In like manner, all the juices abounding with oil are unfit for this purpose; for tho' they contain a salt, yet it is so entangled with the tenacious oil, as to prevent its uniting with the particles of its own nature, and forming crystals; for oil always prevents the crystallization of salts; and again, plenty of oil occasions a loss of salt, and *vice versa*, as well in animals

as vegetables; on which account those salts are not easily obtained from such aromatic plants as abound in oil and balsam.

The use.

Hence we learn the nature of the salt thus obtained, as it is native in plants. It is soluble in water, compounded of oil and salt, frequently acid, and never alkaline: for when it is alkaline, it flies off in the boiling and inspissation. It is moderately fixed, and easily changed; it mixes with the juices, and enters many of the fine vessels of the body; where, therefore, it may exert its virtue. When dried, it in some measure burns in the fire, like the inspissated matters of our fourth process, and afterwards goes into salt, like that of our fifth and sixth process.

PROCESS VIII.

The native salt or tartar of vegetables, from their fermented juice.

(1.) **T**HE expressed juices of ripe summer fruits being perfectly fermented, and so become wine, deposite their fæces, or lees barely by standing, and thus become bright. If now this wine be drawn into a clean vessel, and suffered to rest for a long time, it produces in its body little shining sharp corpuscles, moving about therein. These corpuscles dispersing themselves from the wine's center of gravity to every point of the surface, at length touch, and fix themselves to the sides of the cask, and thus crust them all over, wherever the wine reaches. By degrees the liquor deposite more of this matter, which easily sticks to the former, whereto it seems to be attracted, till at length the whole body of the wine contains no more of it. After this, if the wine, thus grown milder, be drawn off into another cask, and fresh wine, fined down as before, be put into the cask that was emptied, but still remains lined with its crust, the same kind of matter will be sooner generated, and grow to the former crust, which more powerfully attracts it.

(2.) This appears to be the true generation of that strange production, which is the genuine saline crystals of the wine, tho' not like other saline crystals found only in the bottom, but equally all round the sides of the containing vessel. This substance is in many respects different from the lees of wine, tho' it seems nearly of the same nature; but it is more subtile, more pure, less earthy, less feculent, less unctuous, more difficultly soluble in water, and of a more acid taste. The Germans call it by a very proper name, *wine-stone*, but the chemists, less properly, tartar. There is a great difference in it, according to the nature of the wine; the acid austere kinds whereof afford more, but the sweet and oleaginous less. The wines, that have their fermentation stopt before it was completed, afford a less quantity, and those perfectly fermented and become thin, a greater; as *Rhenish* wine for example. The tartar of red wine is red, and of white wine white.

The use.

1. This is another way of obtaining the natural salt of vegetables; which salt is always acid and oily. It is easily changed into an alcali; it dissolves neither in water, wine, nor vinegar, without heat, but remains like a stone therein; and like a strong vessel contains within its crust the wine from whence it shot. It requires a boiling heat before it will perfectly dissolve in water; and then again, as soon as the water begins to cool it immediately begins to become solid in the water, and is then called cream or crystal of tartar. It requires twenty times its quantity of water to dissolve it perfectly. It generates more elastic air in burning than any other known body, and yields a vapour that can no way be confined. It is a great corrector in those bodies which abound with a sharp bilious putrid matter; and hence becomes an approved remedy in acute diseases. It cleanses the first passages, without much disturbing the more internal parts. With a corrupt acrimonious matter it loses its acidity, changes into a very soluble substance, and hence becomes a good aperative remedy. Its other properties will appear, when we come to treat of it hereafter (a).

2. We may hence understand what salt that is, which resides in the natural or fermented juices of vegetables; but we shall shew in our 55th process that these salts, so generated, are easily resolved by art into highly elastic air, a tartish water, a tartish and strong smelling spirit, an oil the most volatile of any hitherto known, a gross and fixed oil, a black alkaline coal, an excellent alcali, and an earth. Salts, therefore, do not exist pure in plants, but are always mixt with other matters. And hence we may begin to understand the nature of the chemical *analysis* of vegetables.

PROCESS IX.

Salt from recent rosemary, calcined, after the manner of Tachenius.

1. **P**UT a quantity of recent green rosemary, with its leaves and stalks, into a large deep and clean iron pan; place an iron plate on the top, so as to press down the plant, and perfectly cover the vessel; which being thus set on a moderate fire gently encreased, is at length to be ignited. Thus the plant will smoke, smell strong, and be turned to a black coal. Add more fresh rosemary to what is already burnt; cover, compress, and proceed as before, till this also is turned to a coal, and repeat the operation till a sufficient quantity is obtained. In the whole of the process the plant must be carefully prevented from taking flame, by covering the vessel close, and perfectly excluding the air, which as soon as ever it enters, the flame bursts out. This operation is called close calcination; and the slower it is performed, the better it succeeds. The plant will now

(a) See process 54, 55.

be very black, and crisp, and bitter; so that if boiled with water it makes a bitter liquor, that will scarce yet afford any salt, but tastes empyreumatical, and proves sudorific; whence by such burning of a plant into a coal, the salt hardly appears either in the lixivium, or by the taste.

2. And now let the iron cover be removed, and the pot with the scorched matter remain on the same fire, when as soon as the free air is admitted, the black mass will begin to ignite, and easily take flame; but this is carefully to be prevented, and the ignition to be kept up by a due regulation of the fire. As soon as the upper part, contiguous to the air, has sparkled for some time, it ceases to be ignited, and then presently turns white, but the parts buried under these white ones remain black, and ignited; whence the whole matter is to be carefully stirred with an iron rod; that all these parts being successively exposed to the air may grow white; so that at length the ignition being general, the stirring perpetual, and the whole exposed for a proper time both to the air and fire, it may be changed into one similar white mass, which will then appear small, ponderous, and universally white; and then there will appear no more sparkling, tho' the fire were increased. But if a single leaf should still remain black, it would immediately sparkle, upon feeling the air, as before. When the whole subject is thus made white, it has a sharp, urinous, and saline taste, which never becomes pure in the plant, so long as any blackness adheres to it; this being no other than mere oil that should be consumed by the fire, and when it is totally consumed, the salt, which remains untouched by the fire, begins to appear naked. Whence we have it farther confirmed, that the oil must be consumed before the salt can be prepared.

3. Let the ashes, so procured, remain for an hour or two over the fire, so as to be kept perpetually ignited, and stirred with an iron rod. And when these three particulars are rightly performed, then is the calcination of vegetables finished for preparing the salt of *Tachenius*. And here this stifled action of the fire drives off the water, intimately unites the salt and the oil into a saponaceous substance; tho' it is still mixt with a large portion of very subtle earth.

4. Put these ashes into a clean iron vessel, along with six times their weight of pure rain water, and boil them over the fire, frequently stirring them with an iron ladle. The floating liquor will thus become sharp, lixivious, and saline, by imbibing the salt out of the ashes, and leaving the earth at the bottom. Let this liquor be strained hot, till it becomes perfectly clear, and afterwards be kept under the title of the lixivium of *Tachenius's* salt. The earth remaining at the bottom of the vessel, and in the strainer, being boiled with fresh water, affords a lixivium, tho' this contains less salt, and rather approaches the acrimony of lime; it may be strained and mixed with the former. The remaining earth may still be boiled with fresh water, and the liquor treated as before, till the water comes off as insipid as it was poured on. The latter lixiviums may be either filtered and preserved, or else thrown away as useless. Let the pure earth that remains be stirred well with rain water, and the turbid part

' poured off; this operation being repeated, till nothing but sand remains at the bottom, which may thus be perfectly separated from the true ashes mixt with the water. Let the earth subside from the muddy waters, and be afterwards dried: it will be the pure elementary and almost virgin earth of vegetables, and proper for making of tests.

' 5. Let this pure lixivium be boiled in a clean iron vessel, till it becomes perfectly dry; observing to stir it continually at the last, lest it stick too much to the vessel. The salt it thus leaves will be sharp, somewhat alkaline, brownish, and gradually relent in the air: tho' not so readily as perfect alkaline salt. The browner this salt is, the better it was prepared; as having more of the oil.

' 6. This salt being put into a clean crucible, and set in the fire till the crucible be well ignited, easily flows like water, or much sooner than true alkaline salt, and should now be poured out upon a clean copper plate: and this is the pure vegetable salt of *Tachenius*.

' 7. If it be required purer, it may be exposed to the moist air, or dissolved in fair rain water, then filtered and evaporated to a pellicle; when being set in a quiet place, it will shoot into pure saline crystalline glebes. These salts contain not acrid alkali, but the oil of the plant here mixed with the alkali, renders it a milder salt. But we are not to expect the particular virtue of the plant in the salt thus prepared; for this is driven away by the fire along with the volatile presiding spirit; and therefore the commonest herbs, if but rich in salt, being thus treated, yield this preparation as perfect as the dearer; their medicinal effects being certainly the same. But the colour of this salt is easily changed in the melting, if any coal should fall into it, upon which a lead colour would immediately ensue, and prove different according to the quantity of the coals.'

The use.

1. These salts are not corrosive or fiery, but of a saline nature, compounded of oil intimately mixed with corrosive alkali by the fire: and they recede the more from corrosive fiery alkali, and prove the more medicinal, the longer the plant was torried, and the more the air was excluded.

2. They are not therefore so opposite to acids, as to destroy so large a quantity of them as fixed alkalies will; but if rightly prepared, they may in some measure supply the want of sea-salt for ordinary uses. Thus *Varro* relates of certain people upon the *Rhine*, that they used salt prepared from certain wood-coals calcined, instead of sea-salt (a).

3. If these salts be long exposed in open vessels to the external air, they attract moisture and dissolve, tho' much more difficultly and slowly than pure alkali; but they readily dissolve in water.

4. They also readily mix with all the juices of the body, even with the fat and inspissated bile, by means of the vital heat, and the action of circulation.

(a) See *Varro de re rustica*, lib. 1. cap. 7.

5. Hence

5. Hence they may be received into the blood-vessels, and those of the serum, milk, lymph, urine, sweat and bile, but not into the nerves.

6. By the help of mixture, heat, diluting, and the vital motion, they may dissolve many coagulations, particularly those found in the juices of the body; especially if assisted by exercise, frictions, and riding: but they do not easily dissolve the stone in the bladder, as a *menstruum*, tho' they lessen it, by means of the motion and mechanical friction which they increase in the body, and principally in the urinary passages. Neither can they reach the diseases seated in the nervous fluids, and therefore do not directly cure the confirmed gout: in other respects, when diluted with hot water, and agitated by the motion of the body, they penetrate deep into it.

7. When these salts are received and mixt with the juices of the body, they have a corrosive effect, tho' not destructive, but sharper than the natural: whence they stimulate the more sensible parts of the nerves, and excite them to perform their vibrations with more than ordinary force; on which account they are highly serviceable in sluggish hypochondriacal and hysterical disorders, and such as arise from mere inactivity.

8. They therefore have extraordinary effects in opening the obstructed vessels of the body, whilst they agitate the nervous system, and at the same time dissolve the grosser matters, and urge every thing in their way with a weight and force greater than those of the natural salts of the body.

9. And hence they exert their virtue in promoting all the secretions and excretions; for as they easily render the fluids more thin, and clear the cavities of the vessels, they at the same time stimulate both the fluids and the solids; and therefore equally excite the true causes of the motion of the juices thro' the vessels, whereon all secretion and excretion, in every part of the body, depend.

10. Hence appears why they are sudorific; since it is certain that the sweat naturally contains the native salts of the body, and deposits them upon the external surface of the skin, thro' the minute open arteries in the cuticula; whence there is a passage open for these salts even to the skin, whereto the faculty of excretion reaches, as is clearly manifest by experiments.

11. These salts are remarkably diuretic, for the kidneys are so formed as to discharge the superabundant salts out of the body; as evidently appears from this, that the urine is the most saline of all the animal juices: whence the operation of these salts is in nothing more evident, than in promoting a discharge of urine, and at the same time cleansing the humours from any peccant foulness.

12. They also loosen the belly, resolve concretions, open the passages, and expel all sluggish matters. The costiveness of hypochondriacal men can be no way better remedied than by a well regulated and a well directed use hereof, continued for some sufficient time: for in this respect, these salts have this extraordinary and particular virtue, that when costiveness is once remedied by their means, it does not return; which is not the case of other purgatives. The whole bilious system, the liver, the spleen, the bladder, the biliary ducts, and the *vena porta* have scarce a safer and more effectual remedy

medy to relieve and help them. Certainly this lixivious soap dissolves the viscid obstructions of the passages, and cleanses them without violence; so that by their means may be obtained that coction or preparation of the humours, recommended by *Hippocrates*, before they ought to be discharged.

13. Hence we should observe the curative virtue of these salts in all those chronical distempers, attended with a mere torpidity of the spirits, a sluggish laxity of the fibres, an inactive thickness of the juices, without a putrid acrimony, an acid sharpness from a weakness of the vital faculties, and a coagulation from any thing acid or austere. Certainly, a large number of diseases proceed from these causes; whence the cure of many chronical cases may be effected by these salts, which destroy acids, turn them neutral, then stimulate by this new virtue, and dissolve viscidities. But we must not rashly imagine their use always proper and innocent: it is adding oil to the fire to give them in putrid, bilious, alkaline disorders, attended with great commotions, and great heats thence arising. They are also prejudicial to those of so weak a constitution, as not to be able to bear their effect, or to sustain with safety the motion they excite, and likewise where the body already abounds with salts.

The method of using these salts in medicine.

1. They are to be taken upon an empty stomach, after digestion is performed, and therefore ten hours from the last meal. Their dose is from four grains to two drams, or more, according to the discretion of the physician, and the difference of intention.
2. They must be diluted with a large proportion of water, lest they should otherwise, upon their first contact, hurt the jaws, the throat, or the stomach: let therefore a dram of the salt be dissolved in nine ounces of common water; for thus they will act like those mineral waters, which have their effect by means of a little fossil salt in a large quantity of water.
3. If the design be to purge, let the patient over night take three pills, consisting of nine grains of washed *socotrine aloes*, or half a dram of the *pilule Ruffi*; let him rise early the next morning, and walk a little in the cool air, but prevent sweating, and drink, whilst he is walking, a proper quantity of the liquor, divided into five or six doses; which will have an excellent effect, and purge and relieve without debilitating. This is the true cure for the costiveness of the studious; and is able to extirpate deep rooted diseases that yield to no other purging.
4. If the kidneys and blood-vessels are to be cleansed, proceed as before, only omit the *aloes* in the evening, and let the loins and hypochondria be more covered than the rest of the body; the patient, between whiles, drinking a dish of tea or coffee.
5. When the intention is to sweat, let the patient take the liquor in the morning in bed, after the same manner; drinking after every draught some gentle sudorific; such as the decoction of burdock root, the five opening roots, saunders, sassafras, tea or coffee, and let the sweating be continued in proportion to the distemper; the body remaining sufficiently covered.

6. In

6. In order to cure stubborn, or autumnal intermittents, whether tertian or quartan, with these salts of *Tachenius*, let the patient be purged with them according to the above direction for two or three days successively. Then four hours before the fit is expected, let him be strongly sweated in the manner just mentioned, about the time of the fit. And thus stubborn agues are happily cured: and in this particular the solution of these salts excels the *Spaw*, or other chalybeate mineral waters.

PROCESS X.

Tachenius's salt from a dry plant calcined; by an example in carduus benedictus.

IF this plant be scorched by fire to uniform black coals, with the same apparatus as in the ninth process; and a large quantity thereof, be then, in an iron pan, set over a clear fire, and turned into uniform white ashes, without suffering any flame to appear, and these ashes be afterwards a little calcined, then made into a lixivium, which being filtered, reduced to salt, and at length fused, there will a salt be obtained, like the former, made from a green plant.

The use.

Since the oil and the salt, which plants have in common, are combined together in these salts, without retaining the specific virtue of the subject, it is of little significance from what plant they are prepared. Whence cheap and refuse vegetables should be used for making it. Thus dried bean-stalks, for example, being thrown on a heap, and pressed down by iron plates, and scorched, in our method, by a gentle fire, will afford a salt of the same virtue, at a much easier price, and therefore principally to be recommended. But it has no peculiar medicinal virtue, tho' *Paracelsus* particularly prefers it before others in the case of the stone. We should only observe not to choose the plants for this purpose too old, or too dry, because they would thus afford little salt, and not be worth the labour; tho' otherwise the salt is sooner, easier, and cheaper prepared from dry subjects.

PROCESS XI.

The salt from a calcined recent vegetable, in the common method of the trading chemists.

TAKE any recent plant abounding in saline matter, as wormwood, carduus benedictus, fern, kali, bean-stalks, or the like; dry them in a warm air, shake off their adhering sand and earth as much as possible; bind them into large bundles, and lay them on an heap upon a brick pavement,

The Practice of CHEMISTRY.

' pavement; then light it in the open air, and suffer it to burn with a clear
 ' crackling flame; throw more bundles successively upon the ignited ashes,
 ' till the whole quantity intended be burnt to uniformly white ashes, as they
 ' will soon become by keeping them constantly stirred with an iron rod.
 ' These ashes, being sifted, are those sold by the people who gather medi-
 ' cinal herbs for pharmaceutical uses. Tho' the phenomena of this process
 ' are common, yet they deserve to be carefully observed: and first, when
 ' the plant is thrown upon the fire, it emits a smoke, which by degrees be-
 ' comes more dense and black; and when thickest, blackest, and in greatest
 ' motion, the flame suddenly breaks out like lightning. An extremely lucid
 ' fire now plays in the flame, where no signs of the least smoke or black-
 ' ness appear. But, 2dly, the surface of the flame, as well the top as the
 ' sides, emits a black smoke, with which they are surrounded, as appears,
 ' by holding a piece of white paper, or clean linen, above the flame. 3dly,
 ' It is remarkable, that the blackest densest smoke, whirl'd in a vortex with
 ' great velocity, so nearly approaches to the flame, which immediately breaks
 ' out, as scarce to differ from it; and when upon any cause the flame ceases,
 ' whilst black coals still remain in the fewel, black smoke immediately fol-
 ' lows the flame; and these interchanges of flame and smoke may be often
 ' repeated. 4thly, A flame may be made so long as much blackness re-
 ' mains in the burnt subject, especially by the force of a blast; but there
 ' will always be less flame and smoke, the less blackness there is; nor is
 ' there ever any strong flame before a blackness appears in the fewel. 5thly,
 ' When the blackness begins to be much consumed, no more flame can be
 ' excited; but ignited shining sparks appear in every black particle, tho'
 ' without any visible smoke. Perhaps, therefore, smoke, flame, sparks, the
 ' oil of the fewel, and the black part of the coals differ very little in their
 ' matter; for as soon as ever all the blackness is consumed, neither smoke,
 ' nor flame, nor sparks remain. Perhaps, the difference is solely owing to
 ' the greater quantity of the fire, and more rapid rotation of the oil thence
 ' proceeding. The salt, procured from these ashes by the method above
 ' mentioned, is much more sharp, alkaline, and fiery, and therefore more
 ' corrosive, more opposite to acids, and more disposing to putrefaction.

The use,

Hence we learn the difference of salts produced by fire, according
 to the different methods wherein it is applied, and are furnished with
 new instruments of medicine and chemistry of an alkaline nature, but not
 pure alcalies; it is also manifest that of all the salts hitherto explained, the
 salts produced by this last method differ by much the least from one ano-
 ther, and therefore may be prepared from any number of mixed plants fit
 for the purpose: for the salts mixed together cannot be distinguished from
 the salt of any one plant, whence the cheapest sorts are as fit for this pur-
 pose as the dearest.

PROCESS

PROCESS XII.

The fixed corrosive, fiery, alkaline salt of vegetables, and its liquor, or oil per deliquium.

1. TAKE any recent, full grown, succulent and green plant gathered in the spring, and burn it, as for making Tacbenius's salt, to ashes, which will thus afford a large proportion of alcali, when treated according to the 9th and 10th process.
2. Or, because the increase of the quantity will scarce answer the trouble and expence, let it be burnt according to the 11th process.
3. Put the ashes into a large earthen vessel, and set them over a strong fire to ignite, taking care to prevent their fusion, because then they would run into glass, and afford no salt; otherwise, the longer they are thus calcined, the stronger alcali they yield; but then the alcali thus produced and made stronger, is the more disposed to dissolve the earth wherewith it is joined, and so become glass, and thus immediately lose all its alkaline nature: for the fire melting the fixed parts of vegetables mixes them together, and converts them into a fixed, transparent and perfectly tasteless gem, which is afterwards long unalterable, and apparently simple: whence the most ancient commentators on the bible have wrote, that at the last day, the frame of the world shall be dissolved by fire, and turned into glass. And if the fire be continued too long, or raised too high, a small quantity of true glass is often found at the bottom of the vessel.
4. Let these ashes boil in an iron pot with four times their weight of rain water, then standing to settle for half an hour, that the lixivium may become clear, pass it thro' a thick linen so often, till it appears perfectly transparent. Boil the fæces again with fresh water, often stirring them with an iron rod, and mix this lixivium, prepared as before, along with the former. Now, keeping back the fæces, boil the pure lixiviums in a clean and bright iron pot, till they begin to acquire nearly the consistence of honey. Then stir the whole strongly with an iron ladle to prevent its growing to the pot in the drying; for if it be once fixed thereto, it cannot afterwards be got off. When it becomes almost dry, the heat being increased, and the greatest part of the water discharged, the matter suddenly swells and rarifies, from the great increase of the heat for want of the water discharged; whence, unless carefully prevented by stirring, the matter would boil over the pot to great loss and inconvenience. The stirring is to be continued till the salt becomes perfectly dry in the pot, white, alkaline, and pure; but it is difficult to procure it perfectly dry, and harder still to keep it so.
5. Put the salt thus prepared, whilst it is yet dry and hot, into a strong crucible, and melt it in a brisk fire, keeping it in this state for an hour or two; then pour it carefully into a metalline mortar made perfectly dry, clean, and hot: in the mean time, have in readiness a vessel of green glass,

The Practice of CHEMISTRY.

‘ glass, made dry and hot, having a wide neck, and a large mouth. As soon as the salt is poured into the mortar, grind it well with a pestle before it grows hard, and thus it will be brought into a dry powder; which can be no otherwise procured, because of its aptness to relent in the air. Then as soon as the powder grows lumpy, immediately put it hot into the dry heated glass above mentioned; which is now immediately to be stopp’d with a new dry cork strongly driven in. Lastly, dip the top of the bottle with its cork into melted pitch; and thus will a pure alkaline salt be obtained.

‘ 6. The stronger and the longer this salt flowed in the fire, the more sharp and fiery it will become, and thus constantly change of different colours; being at first grayish, then white, next bluish, afterwards greenish, brown, and at length reddish or marbled; and the succession of these colours, proceeding only from the force of the fire, always denotes a greater degree of acrimony, or a more alkaline nature. There always seems to remain less of the oil of the plant in this salt, the greater and the more violent fire it sustained. Hence, if we desired distinctly to observe all these differences of the salt, the process might be divided into so many parts, as we have set down different degrees of colour and sharpness. But here the operator must be careful that he be not deceived by the colour, proceeding from the falling in of the coals; for we here understand that colour alone which proceeds entirely from the fire.

‘ 7. In the same manner the juices, extracts, and native salts of vegetables, the tartarous salts that shoot from fermented liquors, and the salts of *Tachenius*, all afford the alkali now described, if treated with the same fire.

‘ 8. There is, however, a remarkable difference in the production of these salts: for some plants afford them readily in plenty, and immediately, of an exceeding sharp alkaline nature: the cuttings of the vine at the beginning of *March*, being burnt in a strong fire, give a copious and strong alkali; which *Basil Valentine* seems to have preferred to all others for preparing his two medicines against the gout and stone. So likewise the *Kali* of *Egypt* is rich in such salt, tho’ it can be prepared from nothing sooner or better than from tartar; and the alkaline salt so made, was judged the best both by *Paracelsus* and *Helmont*. The glass-makers observe, that the glass made of the salt of fern is of a dark green, but with the salt of *Kali* extremely clear; whence this latter salt is recommended for making the finest glass (*a*). And in the Duke of *Tuscany*’s court they discovered upon examination a certain difference in the crystal glass hence prepared, and found different colours arise from a mixture of such different alkalies with a solution of mercury-sublimate in water, and the vitriol of iron (*b*); so that some small difference may proceed from the different origins of this salt, but much more from the different manner of its preparation.

(a) See *Neri* and *Merret*.

(b) See *Tachen*. Hippocrat. chem. cap. 7. and 16. and *Borrich*. contr. Conring. 350.—361.

‘ 9. The

9. The salt, thus prepared, has these properties. (1.) It has a fiery taste; for if a little piece of it be laid upon the moist tongue, it gives the same sensation as a little fire-coal would do, causes a sudden inflammation, and an eschar, which leaves a little ulcer behind it. But when diluted with water, so as not to prove hurtful when held in the mouth, it tastes like putrescied urine; whence these kind of salts have been called urinous; tho' this only proceeds from the salt absorbing the acid of the *saliva*, whilst the other alkaline part thereof becomes volatile, and gives the sensation. (2.) This salt affords no sensible odour whilst it remains unmixed; but if added to any saline substance, whether of the nature of the native animal salts, or sal-ammoniac, their acid part is immediately drawn into this alkali, whilst the other being freed from its fixing acid, always proves volatile, urinous, foetid, and as it were putrescied: whence again chemists have called this salt urinous, being led thereto from this sudden change, which they falsely attributed to the alkali; because such an odour is found in neither before mixing, and because the animal juices immediately upon the application of the salt acquire this new smell and taste. (3.) It is of various colours, but commonly white or bluish (a). (4.) These salts seem unctuous to the touch, and when dissolved in the air, afford an unctuous liquor, which the chemists therefore call by the name of oil *per deliquium*. (5.) If a piece of this salt be applied to the moistened skin, so as to remain fixed in one place, and be covered on the outside to keep it from falling off, it presently dissolves by the natural moisture continually transuding thro' the body, and being agitated by the natural warmth thereof, causes an itching, a heat, redness, a burning pain, a shining tensity, a real inflammation; a hard and black gangrene, and an eschar, deep in the solids of the body, so as truly to act like fire therein. It also turns the bones white; and if bones be boiled in a lixivium of this salt, they remain white when dried. Again, as fire soon putrefies the parts of animals, so likewise our alkaline salt suddenly brings on a foetid corruption, if mixed with them; whence in this respect this salt, when pure, acts like poison, and destroys the animal structure irrecoverably; and therefore is a highly dangerous salt to the body, and imprudently recommended as a safe remedy by the modern physicians. (6.) If mixed with an acid dissolved in water, it presently produces an ebullition, a hissing, and an intestine motion; at the same time generating and discharging a large quantity of elastic air, but at length with a certain proportion of the acid, the tumult ceases, and cannot be recovered by a fresh addition: and this always happens either sooner or later; for tho' the sharp alkali of tartar does not presently manifest an ebullition upon a small affusion of vinegar, yet it does some time after. (7.) When such a fixed alkali is mixed and agitated with the juices of the body, by means of the vital heat, it unites somewhat intimately with them all, dissolves and thins them, joining their acid part to itself, and making their saline part alkaline, which before was neutral or ammoniacal, sharp instead of neutral, extremely volatile instead of half-fixed, less oleaginous instead of saponaceous, and putridly foetid instead of inodorous. But if boiled

(a) See above, §. 6.

with milk, this is coagulated thereby; tho' it rather thus dissolves all the other juices of the body. When therefore by the motion of circulation it comes together with the juices into the small vessels, it corrodes them by its acrimony, particularly the lungs. It likewise dissolves the gummy, resinous, oily and viscous parts of vegetables and animals, as also the fossil oils and sulphurs, and opens, attenuates, and dissolves the viscosities they form. (8.) Being boiled, or long digested in any oils, with the assistance of the air, or water and heat, it is intimately united, and may by art be turned into true soap, thus losing its acrimony, and at the same time destroying the tenacity of the oil, and rendering it miscible with water. (9.) Being long fused in the fire with sand, or powdered flints, in a certain proportion, it intimately mixes therewith, and becomes glass, wherein not the least sign of the salt appears. This transformation is very extraordinary, and if not common, would be esteemed impossible. But when this glass is again melted with thrice its weight of the strongest fixt alkali, it may afterwards be dissolved and diluted with water, and leave its sandy part precipitated by the addition of a strong acid, which here drinks up the alkali; according to the observation of *Helmont*. That this should happen because the sand contains a latent acid, is perhaps too subtly imagined by *Tachenius*. It is plain that the sand and alkali are here united; but whether it depends upon the acid of the sand, or upon the vegetable alkali alone, seems hitherto uncertain. (10.) This *fixed alkali* is a true magnet, or attractive of water, so as to grow soft, moist, spongy and tumid, by attracting the vapour of the air; at length dissolving and running therewith into a fat, thick, and, in some measure, tenacious liquor, called alkaline oil *per deliquium*; which being pass'd thro' a paper filtre, supported by linen, becomes exceeding pure, and the most ponderous of all saline liquors, next to oil of vitriol. From this liquor the water may be recovered in its purity by distillation: but acid particles floating in the air may be attracted by this salt, along with the aqueous, so as to change its nature, and make it approach the nature of those salts that originally afforded the acid. Thus if the acid yielded by burning brimstone predominate in the air of the place, the alkali acquires the nature of tartar of vitriol; if the fumes of spirit of nitre, sea-salt, or vinegar, it approaches the nature of nitre, salt, or regenerated tartar, respectively. If rarified oil were to fill the place, the salt would then become a kind of soap. But so long as this salt remains purely alkaline, it strongly retains all water, and parts from it with great difficulty; whence it is not easy to dry it. (11.) This salt remains long fixed in the fire, tho' fused thereby, provided it be contained in a vessel that does not run; yet by being long fused alone, it at length vanishes, especially if mixed with thrice its weight of calcined bones, or unvitriifiable earth, and long exposed to a violent fire; for in this state, being neither easy to melt, by reason of the earth which prevents it, nor easily vitrifying with it, it becomes volatile, as the excellent *Mr. Boyle* observes. (12.) When this *fixed salt* is exactly saturated with a pure acid, so that neither in the least predominates, then by solution, filtration, evaporation, and crystallization, it affords a true compound salt of that species from whence the acid proceeded; inasmuch that this has been taken

taken for the natural origin of salts; the mother alcali thus receiving the feminal acid, and serving as the universal *matrix* or chaos of salts. Whence some have called the alkaline salts female and the acid male. (13.) By its power of attracting acids to itself, it separates them from other bodies, and hence produces many extraordinary effects. Thus the native and artificial vinegar of vegetables, the spirits of alum, nitre, salt, sulphur and vitriol, are by its means converted into water, upon losing all their acid part. And the salts thus made, are fixed; only that produced from vinegar proves volatile, as thus volatilizing the alcali. (14.) When fused with a proper fire, it is apt to penetrate thro' the pores of earthen, or even metalline vessels, which it corrodes when made of copper or iron. And I have found iron thus eaten when I have covered the crucible with an iron-plate, which thence became brittle; but copper is sooner consumed. This fixed alcali precipitates metals dissolved in acids: and thus it separates the quicksilver in a solution of mercury-sublimate, where the metalline part is held dissolved by the acid of sea-salt; the powder precipitated appearing of the brighter red, the stronger and purer the alcali is made; whence we have a certain method of trying the purity of this fixed alcali. This alcali being mixed with the juice of the sun-flower, roses, violets, &c. turns them green, as acids turn them red. (15.) This salt never appears in its own form either in animal, vegetable, or mineral substances, but arises from vegetables alone, treated with a violent fire, of which it is therefore the creature, produced in vegetables burnt to ashes: for in this action it is always prepared. When mixed with ashes, it turns into earth, and there appears no longer in its own nature; but by passing thro' the same revolution, it may again be formed into the alcali it was before. (16.) This salt being run *per deliquium*, then dried, again melted in the fire, and again run by the moisture of the air, thus by repeated operations at length resolves into earthy faeces, and a volatile part. And thus by faithful experiments we learn the nature of fixed alcali, such as we theoretically described it in our *chapter of menstrua*; which account being compared with the present, we may form a true judgment of the thing that has been so famous for these two last ages among chemists and physicians; and hence be surprized to see how little they knew of what they have both wrote so much about.

10. If we would justly relate the medicinal virtues of the present salt, the result will be this. (1.) It soon destroys all the acid in the body; this acid being there but little, mild, of a vegetable nature, and lodging only in the first passages. (2.) It makes an effervescence upon meeting with an acid in the body; thus exciting bubbles, and causing windy vapours, stimulating the parts by its motion, and turning to a neutral salt, which then becomes innocent, penetrating, aperitive, diaphoretic, diuretic, preservative, and produces new effects, not properly ascribed to alkaline salts, tho' they follow upon the use thereof. (3.) By the motion of this effervescence the nerves are stimulated, the spirits moved, and the former motion both of the nerves and spirits altered; hence the spasms of hypochondriacal and hysterical patients are often cured, with the distempers thereon depending, as we see in the famous anti-emetic of *Riverius*; which being a mixture of fixed alcali, and the

the juice of lemons, and drank in the act of its effervescence, cures choleric disorders, and stops violent vomitings that yield to no other means. (4.) It thins the juices that coagulate with acids, and has therefore excellent effects, being prudently given in coagulations of the milk (a). It also successfully dissolves other viscidities. (5.) It attenuates glutinous, oily, and fat substances, rendering them miscible with water, whence it has a cleansing virtue. And hence, a lixivium of this salt has its scouring property, as is observed by *fullers, scourers, and dyers*; and hence, by a moderate use, it cleanses the whole system of the chyle-vessels from their glutinous matter. (6.) It also dissolves the coagulations of the bile, lymph, blood and serum, being carried to, and agitated among them by the force of the circulation. (7.) By its stimulating virtue it excites the unactive parts, and thus promotes a discharge of urine, sweat, and saliva, so as to be accounted diaphoretic, diuretic, and sudorific; it also loosens the belly. (8.) It is therefore of excellent use in distempers attended with sluggish, viscous phlegm, an acidity from vegetable aliment in the first passages, an austere acid humour, manifest effects of coagulation, a collection of watery serum, unctuous and viscid concretions, and in the diseases frequently arising from these causes; as the dropsy, jaundice, *leucopneumonia*, gout, rheumatism, and scurvy: but it ought to be given cautiously, well diluted, in a small dose, and at proper times. Perhaps, that species of the gout which proceeds from too great acidity, can scarce be better cured than by a moderate use of this salt, continued for some time; but it must not hence be presently commended as an universal remedy for the gout: for it proves hurtful where this distemper happens in bilious constitutions; the juices in this case spontaneously tending to a putrid alkaline nature. (9.) This salt is of great service in chirurgery, where it is used for the making of issues in the way of a caustic; and putrid foul ulcers are excellently cleansed by a mild lixivium made of it. If gangrenated parts be scarified to the quick, and afterwards fomented with this lixivium, they grow crusty, may be easily separated from the sound flesh, and thus the spreading of the mortification is hindered, and often cured. It extirpates warts, and safely eats away little cancers, and, if sufficiently diluted with water, it excellently takes away spots in the skin. (10.) But the use of all these salts is pernicious in those distempers where the native salts begin to degenerate into a corrosive, alkaline, putrid, and volatile nature, and the natural oils of the body tend the same way, known by a rank exhaling odour of the skin, and the high colour of the urine; but they are then principally fatal when the bile is thus altered, and the juices too much dissolved, broke, and turn'd corrosive. Whence in the plague they are almost immediate poison, even in the form of soap. Their internal use therefore is to be wholly avoided in inflammations, suppurations, gangrenes, sphacelations, continued putrid fevers, and diseases attended with too great a velocity of the blood. (11.) To use them cautiously, let a dram thereof be dissolved in twenty times its weight of water, and scarce more than a dram of this be ventured upon for a dose; which should be repeated with prudence, and a due observation, during the use, whether the farther occasion for it be not

(a) Tho' itself coagulates milk when boiled therewith, see above §. 9. (7.)

ceased,

ceased. And thus these salts may be advantageously used without danger. In the last place, their effects ought to be directed upon particular parts of the body, as was observed in giving the salt of *Tarbenius* (a).

PROCESS XIII.

The highly corrosive, fiery, alkaline salt with quicklime.

“TAKE one part of quicklime fresh prepared from stone, and put it; whilst it remains perfectly dry, solid, and unerack’d, into a clean iron pot; lay upon it two parts of pure pot-ash, so as every way to cover the lime. Cover the pot with a linen cloth, and leave it in this state till the lime begins to split; then add four times their weight of fair water, and boil them together for an hour or two. Strain the clear lixivium thro’ a close linen bag made of a conical form, till it becomes as limpid as water; then inspissate this lixivium in a large iron ladle, with care to prevent boiling over, till it becomes perfectly dry; making the fire so strong at last as to ignite the ladle, and melt the matter, after it ceases to fume. As soon as it runs, pour it out upon an hot copper plate, and whilst it is yet soft, make it flat, and cut it into little sticks fit for chirurgeons use; put the pieces immediately into a strong heated and dry glass, which must be directly stop’d with a sound and dry cork, and then be carefully closed over by having its upper end dipped in melted pitch, to prevent any moisture from insinuating; which with incredible force is attracted by the alcali so prepared, even thro’ cork and bladder. But by this contrivance it may be kept perfect for years. When any part is taken out for use, this should be done in a strong heat, near the fire, and in a dry air; the glass being again immediately closed as before.”

The use.

1. The salt acquires a very strong and quick corrosive power on this account, that the fiery fixed alcali attracts the fiery virtue of the lime: for no such power resides either in the alcali, or lime alone. This corrosiveness exceeds that of any other known salt; for if a little piece of it be applied to the skin, contained in a small round hole cut in a plaister, first laid upon the part, and then covered with another plaister, it soon burns the skin and the fat; for which reason chirurgeons prefer it as their chiefest potential cautery.

2. While the fresh lixivium is boiling over the fire, it will immediately dissolve almost any animal substance thrown into it, as also many vegetable matters, and fossil sulphurs. A man unfortunately falling into a boiling copper full of this lixivium, had his clothes, and all the soft parts of his body dissolved, so that only the bones remained. But a prudent ap-

(a) See process 9. method of using, &c.

The Practice of CHEMISTRY.

plication of such a lixivium, is an incomparable remedy for disposing deep gangrenated, and almost sphacelated parts of the body to a curative separation; tho' its application requires the caution of an experienced surgeon.

3. This salt melts and runs like wax with a gentle fire, and hence becomes fit for dissolving many things with a small degree of heat, which are otherwise of difficult solution, such as myrrh, gum-sandarac, &c. The ancient chemists have wrote much upon the art of rendring fixed alcalies fusible, like wax, in the fire, under the title of *Inceration*; possibly they might mean the present process, at least the salt it affords has this property.

4. If the lime were first slacked either in the air or in water, as almost all old lime is, or be already reduced to fine powder, it will not give this corrosive salt with fixed alcali. Even the salt itself, if once dissolved in the air, or if kept negligently stopt, loses its particular virtue, and deposits a large quantity of unactive stony faeces, which did not appear before. Whence we learn, that indolent stone, or animal shells, may receive this corrosive power from the fire, tho' not otherwise easily procurable. This might lead one to suspect, that the vegetable salt likewise, when it changes from neutral, native, and saponaceous, to fixed alcali, receives its acrimony from the fire.

5. The salt of this process acquires this particular property, that it becomes extremely well-disposed to unite with oils, whether expressed, or distilled, vegetable or animal, and thus forms soaps; being by the preparation rendered so penetrating, as intimately to divide the body of oil, and unite therewith, which, unassisted with the sharpness of the lime, it could not well do: nor will fixed alcali easily melt at the fire without this assistance.

And here the power of chemistry upon fixed alkaline salts terminates; at least, I know not how to proceed farther in this subject; and will therefore subjoin a few corollaries to these processes.

COROLLARIES.

1. **T**HE fixed salt of vegetables is produced by burning only proper subjects of this operation: for some plants, when burnt, scarce afford this salt; and those fitted to afford it, lose all the matter thereof by lying long exposed to the air, and being alternately dried and moistened a number of times; for the perpetual motion of the fluid air, by drying and heating the subject, in this case acts upon the matter of the second process, and carries it off; which shews that what is spontaneously volatile in the plant, becomes fixed in a calcining fire.

2. Fixed, vegetable, alkaline salt is obtained only by means of a fire that burns the subject; for it is never found in the matter of our second nor seventh process, but only by means of a burning fire; and according to the different degree thereof, and different time of application, it becomes stronger, more fixed and alkaline, according to our twelfth process. It's true, something alkaline appears in mustard-seed, by its manifestly making an ebullition

ebullition with acids, but this is not fixed, but volatile, and vanishes in burning. Indeed, these two corollaries, which are necessary to be known, are supported by all the preceding processes; which plainly demonstrate that this fixed alkali is the creature of the fire.

3. Alkaline salt, therefore, is not the native fixed salt of the plant: I call that salt native, which is produced, by the particular nature of the plant, from the common nutritious juice of the earth, and therefore always remains in the plant, so long as this is left to its own nature; which is destroyed by the fire, and changed to another. Our seventh process shewed, that sorrel abounds with a native acid salt; but when this plant is burnt in a naked fire, it affords a fixed alkali, tho' it before contained a manifest acid. This alkali, therefore, is not native, but made an alkali by the fire, from what was not an alkali before.

4. Hence we may understand what an alcalescent plant is: for, first, such are so called whose juice smells sharp, somewhat alkaline, and always volatile, as we find in garlick, onions, and the like. Secondly, those which by a sharp stimulating virtue increase the motion of the animal fluids in the vessels, and thus cause the animal salts to degenerate, or incline to an alkaline nature; whence the sharpest aromatics, tho' in themselves not alkaline, yet give the salts of the body that tendency. And thirdly, those plants from which the fire produces a large quantity of alkaline salt.

5. Hence there are numerous species of fixed salts between the native salt of our seventh process, and that violently alkaline one of the twelfth; and differing from each other in their physical actions, and internal nature, and therefore to be distinguished. For example, *Rhenish* tartar is a perfectly acid, and somewhat sharp native salt of wine; and hence extremely useful in alcalescent, bilious, and putrid disorders. This salt being distilled in a glass retort, with a gentle fire, affords a little watery, tart and light liquor, which quenches thirst; when this is come over, the matter remaining in the retort begins to grow alkaline, and would heat the body, and occasion thirst; if urged with a somewhat stronger fire, it affords a fragrant, penetrating, gold-coloured, bitter and heating oil; leaving a black mass behind, more alkaline, heating, and more apt to excite thirst; but being digested with spirit of wine, affords an excellent aperient, detergent, diuretic medicine, good in the dropsy. If the remaining matter be now urged with a still fiercer fire, it yields a gross, viscid, bitter, foetid oil, leaving a black coal at the bottom of the retort, much more alkaline; this coal being taken out, put into a crucible, and long urged with a violent fire, at length affords a fixed alkaline salt, which continually differs in all respects, but always grows sharper, according to the strength and continuance of the fire: in this instance, the salt was at first of a native acid nature, but at last is rendered highly alkaline.

6. There are three principal causes that contribute to this difference in these alkaline salts; the first is the quantity of inflammable oil still adhering to the saline matter; for the more of this oil, the less sharp the alkaline salt will prove, and *vice versa*. The second proceeds from the artificial union of this oil with the alkali; for if the subject be slowly torried with a stifled fire,

The Practice of CHEMISTRY.

according to our ninth process, the less alkaline and sharp the salt will be, but in greater quantity; but if immediately burnt with the open flame of a violent fire, so much the less in quantity, but the more strongly alkaline. The third cause appears to be the proper action of the fire, which seems to superadd something igneous to the salt; whether it be by the fixing of the fire therein, or by its changing power, as we have explained it in our present process. It is certain, that the longer quicklime is burnt, and with a stronger fire, the more heat, that is, the more true fire it excites in cold water. Perhaps a fourth cause might be added, *viz.* the original and seminal property of the plant, not easily to be destroyed; for one plant affords much fixed salt, and another none at all; not, perhaps, because this naturally contains less salt, but because the plant would not suffer it to be fixed; whether this be owing to the salt itself, to the oil, to the earth, or rather to them all together.

7. From the whole we learn the origin of alkaline salts in animals, by regarding the matter of their aliment, drink, and air: for animals, that feed wholly upon vegetables and pure water, take into their bodies the matter from whence we produce these salts; tho' no one would suspect any thing should be contained in so insipid a substance as grass, that by bare burning becomes so sharp, alkaline and fiery. Neither can the same substance be discerned in beer or wine, yet experiments will shew it; and even the action of animal bodies will disclose and manifest it. The child that is fed with nothing but sweet milk, daily discharges a salt acrimonious urine, not by generating, but by extricating the salt, or bringing it from concealment. The ox that feeds upon herbs, for the same reason, has a very saline urine: but by what means this salt becomes volatile in animals, we shall shew hereafter in treating upon the animal salts (a).

PROCESS XIV.

Corrosive, fixed, vegetable alkali yields a bitter crystalline, hard, fixed, unalkaline, and somewhat glassy salt.

PUT six pounds of the best pot-ashes into a clean glass; add thereto twenty pints of cold rain-water; then stir them about with a stick, and suffer the whole to rest: when the ashes are sufficiently dissolved, gently decant the clear lixivium, and there will remain at the bottom, mixed with the fæces, a number of small gray-coloured grains, of a bitter taste, and almost glassy brittleness and hardness, that afford no signs of an alkaline nature; and the salt intended is procured. But to obtain it in greater purity; put six pounds of *pot-ash* in a copper vessel, with four times its quantity of water, and strain all the lixivium very hot, thro' a linen bag, so as to make it pure; then put it hot into a clean glass vessel that is ready heated and moistened, and suffer it to stand thus; when a dusky crust will presently begin to shoot to the bottom and sides of the glass, and gradually grow thicker and darker. At length, when no more appears

(a) See process 97, 98, &c.

to shoot, gently pour off the liquor; and a salt like the former will remain behind, but purer, and in a large quantity. If the remaining lixivium be now thickened by boiling, and set to rest as before, it may, perhaps, afford a little more of this salt; but afterwards no more; whence there seems to be only one certain quantity of it contained in the alcali. If this salt be shook in a vessel of rain water, it does not dissolve; and nothing more than the alcali is thus washed off, so as to leave the salt perfectly pure. And if it be now gently dried, it becomes simple, and may thus be kept, under what title any one is pleased to give it.

The nature and use of this salt.

1. It has long obtained among the skilful in chemistry, that genuine, fixed, alkaline salts could hardly be crystallized; which is true. But later writers have produced the salt of the present process for a crystallized alkaline salt; without properly distinguishing between them: for it may still be difficult to crystallize pure alcali, tho' crystals may be obtained from it.

2. This salt never runs spontaneously in the air, nor easily dissolves in cold water; when boiled, requires a large proportion of water to dissolve it; and when cool, presently shoots out of it again. It is hard, brittle, and reducible to fine flower, that remains dry. It is lastingly bitter to the taste. It cracks and leaps violently in the fire. 'Tis neither acid, alkaline, nor of kin to any salt hitherto known; tho' it seems to approach nearest to *Sandiver*. This may suggest a query, whether the fire in producing the fixed alcali, does not at the same time produce this salt from vegetables? or whether by combining the sand and alcali together in the making of glass, the fire does not again separate and throw up this salt in *Sandiver*? Something of this kind seems to be the case; whence we may, perhaps, understand why the alcali of tartar does not afford this salt; for tartar proceeds from a subtil liquor intimately fermented in its smaller parts. But a farther application of this salt to various bodies, by the means of fire, must teach its virtues and effects, which are not hitherto sufficiently known.

3. The fixed alcali perfectly separated from this salt differs greatly from that which remains mixed with it; which I always separate before I make any experiments that require the use of pure alcali, whose virtues otherwise would be often disturbed or hindered.

PROCESS XV.

The common distilled water of a fresh plant, by the alembic, shewn in rosemary.

OUR five first processes having shewn what substance remains in plants after such a force of fire is used, as, after the natural degree of heat is capable of being applied to them thro' water; the law of method requires that we should next enquire into that part, which, being separated

by the heat of boiling water, flies off into the air. The most commodious operation for this purpose is that performed by a still-head, closely fitted in to the mouth of a vessel, so as to collect and condense the vapour arising by the boiling heat, and transmit it, without loss, into a receiver. It will hereafter appear what volatile matters are separable from vegetables, by a heat greater than that of boiling water, even up to the highest degree our vessels will sustain (a). But that we may proceed distinctly, we are now to collect that which flies off from a recent plant by the natural degree of the summer's heat up to that of 214 degrees. And for this purpose, we shall again make choice of rosemary, that the operation may be duly compared with those already performed upon the same subject; tho' instead of this, any other of the sapid and odorous plants, enumerated as fit subjects for the first process, might be here employed. All which, we see by the preceding processes, contain an inflammable, oily, and a fixable saline part, as also a saponaceous one, consisting of the two. The plants designed for this operation are to be gathered when their leaves are at full growth, and a little before the flowers appear, or before the seed comes on; because the virtue of the subject, expected in these waters, is often little, after the seed or fruit is formed; at which time plants begin to languish. The morning is best to gather them in, because the volatile parts are then condensed by the coldness of the night, and kept in by the tenacity of the dew, not yet exhaled by the sun. This is understood, when the virtue of the distilled water principally resides in the leaves of plants; as it does in mint, marjoram, penny-royal, rue, and many more. But the case differs when the aromatic virtue is only found in the flowers; as in roses, lilies of the valley, &c. in which case we choose their flowry parts, whilst they smell the sweetest, which should be gathered before they are quite opened, or begin to shed; the morning dew still hanging upon them. In other plants the seeds are to be preferred, as in anise, carraway, cummin, &c. where the herb and the flower are indolent, but the whole virtue remains in the seed alone, where it manifests itself by its remarkable fragrance, and aromatic taste. We find seeds chiefly possessed of this virtue when come to perfect maturity. We must not omit that these desirable properties are found only in the roots of certain plants, as appears in avens, and in orpine, whose root smells like a rose: and here the roots should be gathered for the present purpose, at that time when they are richest in these virtues; which is generally at that season of the year just before they begin to sprout, when they are to be dug up in a morning. If the virtue here required be contained in the barks or woods of vegetables, then these parts are to be chose for the purpose.

1. The subject being chose, let it be bruised, or cut if there be occasion, and with it fill two thirds of a still, leaving a third part of it empty, without squeezing the matter close; then pour as much fresh rain water upon it as will fill the still to the same height, that is two thirds, together with the plant. Fit on the head exactly to the neck of the still, so

(a) See process 32—36, 55, and 86.

that

that no vapour may pass thro' the juncture, which the copper-smiths can order to perfection. Let the joining of the nose of the still-head to the worm be luted with a stiff paste, made of linseed meal and water. Observe, that the cavity of the worm, be always cleansed by passing fair boiling water thro' it, lest otherwise the distilled water should be fouled. Apply a receiver to the bottom of the worm, that no vapour may fly off in the distillation, but that all the liquor, being cooled in the worm-tub filled with cold water, may be collected; which is best performed by keeping the worm-tub continually supplied with cold water.

2. Things being in this state, digest for twenty-four hours with a moderate degree of heat, of 150 degrees. Afterwards raise the fire so as to make the water and the plant boil; which may be known by a certain hissing noise, proceeding from the breaking bubbles of the boiling matter, as also by the pipe of the still-head, or the upper end of the worm becoming too hot to be handled; or the smoking of the water in the worm-tub, heated by the top of the worm; and lastly, by the following of one drop immediately after another from the nose of the worm, so as to make an almost continued stream. By all which signs we know, that the requisite heat is given; and if it be less than a gentle degree of ebullition, the virtue here expected will not be raised: but when the fire is too great, the matter hastily rises into the still-head, and fouls the worm and the distilled liquor; and the plant being also raised, it blocks up the worm; for which reason it is proper to place a piece of fine linen artificially at the end of the still-head pipe, that in case of this accident, the plant may be kept from stopping up the worm. But even in this case, if the fire be too violent, it will throw up the herbs into the still-head pipe, whence the passage being stop'd, the rising vapour will forcibly blow off the head, and throw the liquor and steam about, so as to do much mischief, or even to suffocate the operator, without a proper caution; and the more oily, tenacious, gummy, or resinous, the subject is, and consequently the more frothy and explosive, the greater danger there is in case of this accident.

3. Let the due degree of heat therefore be carefully observed, and equally kept up, so long as the water distilling into the receiver proves white, thick, odorous, sapid, frothy, and turbid; for this water should be kept carefully separated from that which will follow it; whence the receiver must be often changed, that the operator may be certain that nothing but this first water comes over; for there afterwards rises a water that is transparent, thin, and without the peculiar taste and odour of the plant, but generally somewhat tartish and limpid, tho' somewhat obscured and fouled by white dreggy matter: and if the head of the still be not tinned, the acidity of this last water causes it to dissolve the copper, so as to become green, nauseous, emetic, and poisonous to those who use it, especially weak persons and young children; as operating both upwards and downwards with severe gripings. If such a misfortune should happen, it is remedied by drinking plentifully of milk, sweetned with honey, or of the common emollient decoctions.

4. The

4. The first water, above described, chiefly contains the oil and presiding spirit of the plant, and always somewhat saline, which in most plants is acid, but in the more pungent antiscorbutics a volatile alcali: for the fire, by boiling the subject, dissolves its oil, and reduces it into small particles, which are carried upwards by the assistance of the water, along with those parts of the plant that become volatile with this motion. And if the vessels are exactly closed, all these, being united together, will be discharged without loss, and without much alteration into the receiver annexed; for if we may trust our senses, these waters are richly impregnated with the odour, taste, and particular virtues of the volatile parts of plants. Hence, if the botanist justly assigns the virtues of any plant, as they are contained in that part which is volatile by a boiling heat, the chemist can present those virtues separated from the rest. The former was attempted by Mr. *Tournefort*, in his book of plants spontaneously growing about *Paris*, and by Mr. *Ray*, in his book of the native plants of *England*. *Dodonæus* has, perhaps, spoke too boldly, and sometimes rashly of them all, especially in the last edition of his work, printed at *Antwerp* in 1644. I have expressly observed, that the first of these distilled waters contains only the virtues of the plants, residing in that part which is volatile with this heat; because in the whole mixed juice of the plant there is a certain virtue depending upon a mixture of this first water, and the liquor remaining after that is drawn off. The fresh expressed juice of recent mint has certainly many other distinct properties than the distilled water thereof. Whence physicians are to observe, that the virtues of this water, and of the native juice, are not the same, but very different.

5. The water of the second running wants the volatile part above described, yet scarce brings over the more fixed part of the plant, except what is somewhat acid and vapid. If when this is come off, fresh rain water be poured upon the remaining plant, and boiled therewith, or strongly distilled, there rises a more acid water, containing very little of the particular virtue of the plant; almost the same kind of acidity appearing to rise thus from them all at last. This I may venture to affirm upon experience, that the virtue of destroying worms, which the more celebrated physicians have justly attributed to certain distilled waters, depends upon this, that the acid of the water of the last running dissolves the copper, and thus acquires a virtue not its own. This operation, however, shews, that plants contain an acid salt so volatile, as to rise and separate from the subject with 215 degrees of heat. But experience shews, that the water of this second running has scarce any other virtue than that of cooling; as may be safely tried by using a glass still-head instead of a copper one, by which means the inconvenience of its dissolving the copper is prevented.

6. And this is the best method of preparing the distilled officinal waters, provided the two sorts be not mixed together, for both of them would be spoiled by such a mixture; they also spoil with keeping, and will seldom

' seldom remain perfect a year, but degenerate like those formerly mentioned (a).

PROCESS XVI

The use.

We learn from the present process, (1.) what a plant parts with by the heat of boiling water; viz. the water of our first process, the volatile oil with its inherent spirit, and a saline acid. (2.) What remains in the still after the separation of these three parts; viz. the extract of our third process, together with the preparations it afforded in the fourth, fifth, sixth, seventh, ninth, tenth, eleventh, and twelfth. (3.) In what part the odour and taste of a plant reside; viz. in the water of the first process, in the volatile oil contained in this water, and in the spirit contained in this oil. (4.) Hence is easily known what exhales by boiling, both in cookery and pharmacy, and what remains behind. If cornary, chervil, baulm, or smallage be boiled in broth, they lose their peculiar smell and taste, with the virtues thereon depending, and only leave behind their common ungrateful parts; but if cut small, and added to the soup already prepared, and kept hot, but not boiling, in a vessel close covered, so as to infuse for a while, they communicate their peculiar virtues thereto. Cinnamon affords an extremely grateful water, which surprizingly warms and exhilarates; but when this is all come over, there follows another that is acid and indolent, leaving an acid, austere, and cooling decoction behind, resembling that of oak-wood. (5.) Hence it plainly appears at what time, with the same force of fire, quite contrary virtues may arise from a plant; for so long as a milky water comes over from such plants as are aromatic, so long the water remains warming and attenuating; but when it comes thin and pellucid, it is acid and cooling. (6.) In the last place, we have hence the true foundation for the conducting of distillation; for if the operation be stopt as soon as ever the white water ceases to run off, the preparation will be valuable and perfect; but if, thro' a desire of encreasing that quantity, more be drawn off, and so the latter acid part be mixed with the first running, this spoils the whole. We should here observe by the way, that the distilled waters of inodorous plants which have no aromatic sharpness, may yet leave very considerable virtues; though the contrary is generally supposed (b). And again, that the native virtues of vegetables may thus in some measure be changed by the boiling, from what they originally are. The rosemary remaining in our present process still appears green, and preserves its original form; being only deprived of its native smell and taste.

(a) See process 1. nature and uses.

(b) See process 1. nature and uses.

PROCESS

PROCESS XVI.

The common distilled water by the alembic, cobobated or returned back upon more of the fresh plant.

THE last process has shewed what water and fire may separate from a plant in close vessels, and what is left behind therein; but the present process teaches a method of opening plants still farther, and treating them so as to obtain distilled waters much richer in those virtues of the subject, which were mentioned in the former process.

Take the plant and liquor remaining in the still after the preceding process, and press them strongly in a strainer, that all the decoction may be obtained, and with this mix all the water before drawn over. Return this mixture into the still, and add to it as much of the same recent subject as was employed before, and if necessary, add likewise as much water as may make up the former proportion to the plant. Now close the vessels exactly, and digest the whole, with 150 degrees of heat, for the space of three days and nights, that the herb being so long steeped in its own liquor, may be opened, loosened, and disposed the easier to part with its virtues. This digestion being so long continued, is of great service; but if protracted too long, introduces a change tending to putrefaction. Let the water now be distilled off in the same manner as in the foregoing process, only proceeding more cautiously, and somewhat more slowly at the first; because the liquor in the still being now thicker, more impregnated with the plant, and therefore more flatulent, and apt to swell upon feeling the fire, it easily boils over; but after about one half of the expected water is come off, the fire may be prudently raised. If the rule before laid down be observed, and the distillation be continued so long as the first water described in our last process comes over, and then the operation be immediately stopped, the water so obtained will be whiter, thicker, more odorous, sapid, frothy and turbid, than that of the last process. This water also preserves its virtue much longer, and contains it in greater perfection than that of the last process; which shews us a way of concentrating the peculiar virtue of plants, so far as it resides in their volatile odorous parts. So likewise the remaining decoction in this process is much stronger than in the former; and as the operation may be repeated as often as one pleases, both the water and the decoction may by several repetitions at length be made extremely rich; so that by this means excellent medicines are procurable. Thus in the year 1730, I distilled baulm after this manner fourteen times successively, and found the water at last had a balsamic taste, and the perfect fragrance of the plant, so as to prove highly refreshing, even when barely smelt to, or tasted. And no wonder, since the virtue of many large baskets of baulm were here concentrated, and brought within the compass of a small glass; and the remainder also at the bottom of the still being inspissated, filled but another glass, and proved grateful, austere, and strengthening; so that by mixing the two together, the virtues of the plant might be thus

thus highly concentrated, or brought into a very little room. This process therefore does not only afford excellent waters, but admirable extracts also; which, when properly mixed together, yield medicines of such efficacy as can scarce otherwise be imitated. For, the native virtues of vegetables are little changed in this operation; certainly less than in others; tho' it must be allowed, that some alteration is produced by so long a continuation of the boiling. But both the odour, taste, and effects demonstrate, that the waters, thus prepared, retain, in an high degree, the specific virtues of the plant.

And hence it is certain, that the sought medicinal virtue of truly aromatic vegetables resides in that part of them which rises with the heat of boiling water; and that it is possible by art to concentrate their virtues, so that they shall prove much more effectual than in the state they are naturally afforded. Nor is there any limitation; for by continuing to repeat the operation, the virtues of plants may be thus exalted to any degree the artist shall think proper: which shews the extraordinary power of chemistry.

Paracelsus assures us, he found, by experience, that baulm is possessed of so great a specific virtue, as by insinuating into the humours of the body, to restore a new youthful vigour to the aged, and by this means perfectly cure the gout. And *Isaac Hollandus* avouches the same. Now, if these authors said true, I judged I might, by means of the present process, procure the united virtues of the plant in their utmost strength; and indeed, I have in myself experienced extraordinary effects of the water so prepared, by taking it upon an empty stomach. And certainly, it has scarce its equal in hypochondriacal and hysterical disorders, the *chlorosis*, and palpitation of the heart; as often as these diseases proceed rather from a disorder of the spirits, than any collection of morbid matter; tho' it is indeed expensive. I have reduced dried mint, by three or four cohobations, into a balsamic penetrating liquor, which becomes an incomparable and present remedy for strengthening a weak stomach, and curing vomiting proceeding from a cold viscous phlegm lodged about the mouth thereof; as also in lenteries. The water I have in this manner prepared from lemon-peel has, by its fragrance, its agreeably penetrating and highly aromatic taste and virtue, immediately cured flatulencies, deliquiums, faintings, and irregular motions of the heart, tho' taken in a very small dose. The like water, prepared by repeated cohobations from recent wormwood, has successfully supplied the want of bile in the body; stimulated all the languid vessels that help in forming the chyle, and killed and expelled worms. The like water from the leaves of savine has given an almost incredible motion to the whole nervous system; so as to prove the most excellent of all the medicines for promoting the exclusion of the fœtus, the discharge of the menses and hæmorrhoides. The cohobated water of rue can never be sufficiently recommended for the cure of the falling sickness, the hysteric passion, for expelling poison, and promoting of sweat and perspiration. I do not here mention the water I have thus made from the berries of the juniper tree, and the leaves of the *arbor vite*: both of them successfully curing the dropsy, as that from camomile flowers cures tertian agues. It were endless to pursue these waters thro' all the variety of subjects: I judge it

manifest upon the whole, that this is a true and excellent method of obtaining the chemical distilled waters. Some rules, however, are required for applying these two general examples to all sorts of herbs, which may require something peculiar. These rules are as follow.

(1.) Let the aromatic, balsamic, oleaginous, resinous, gummo-resinous, and strong smelling plants, which long retain their natural fragrance, such as *arbor vite*, baulm, bays, hyssop, juniper, marjoram, mint, origanum, pennyroyal, rosemary, sage, &c. be gently dried a little in the shade; then digest them, with the quantity of water already mentioned, for seventy hours, in a close vessel, with 150 degrees of heat, and afterwards distil in the method above delivered; and thus they will afford excellent waters.

(2.) When waters are to be drawn from barks, roots, seeds and woods that are very dense, pondrous, tough and resinous, let them be digested for three, four, or more weeks, with 96 degrees of heat, in vessels perfectly closed, with a proper quantity of salt and water to open and prepare them better for distillation: a considerable quantity of sea-salt is here added, partly to open the subject the more, but chiefly to prevent putrefaction, which otherwise would certainly happen in so long a time, and with such a heat as is necessary in this case, and so destroy the odour, taste and virtues required. And thus, for example, may waters be prepared from aloes, box, cedar, guaiacum, juniper, rhodium, and the like woods.

(3.) Those plants which diffuse their odour to some distance from them, and thus soon lose it, should immediately be distilled after being gathered in a proper season, without any previous digestion; thus burrage, buglos, jasmin, white lilies, lilies of the valley, roses, &c. are hurt by heat, digestion, and lying in the air. Some woods also are hurt in the same manner; thus the shavings of sassafras, by being boiled in water, soon lose their virtue, taste and smell.

(4.) The astringent, nutritive, healing, consolidating, emollient, farinaceous, gelatinous, cooling and styptic virtues of plants are never, by this means, communicated to the distilled waters; but are to be sought either in the whole plant, or its more fixed part. Whence pharmacy should be relieved from the unnecessary trouble of preparing such waters; and on the other hand, physicians are diligently to be admonished to seek for such virtues in the infusions, decoctions, and extracts of such plants. Would it not be ridiculous to expect any thing nutritive in the indolent and vapid distilled water of barley, or minced capon's flesh? Can any man expect to find the excellent virtues of sorrel, in hot, lax, putrid, and bilious constitutions, from the distilled water of this plant? So again it were absurd to attribute the inimitable virtues of plantain to its distilled water. Such idle and childish trifles are therefore to be rejected in the serious arts of chemistry and medicine.

(5.) The case is far otherwise in those plants, whose real virtue entirely resides in that part which is separable by a heat not exceeding 214 degrees; for the waters carefully prepared from these will contain all the virtue which is left in their decoctions and extracts. The celebrated virtues of lavender flowers, lilies of the valley, and of rue, against that species of the falling-

falling-sickness which proceeds from a disturbance in the motion of the nervous fluid, reside in the distilled water, but is absolutely wanting to the decoctions or extracts; so on the other hand, the anti-epileptic virtue of piony remains in the decoction, but is wanting in the water.

(6.) There are some medicinal plants whose virtues reside in a part which is volatil, with the aforesaid degree of heat, but so that after these are raised by distillation, the remaining plant and its decoction continue possessed of other virtues, and proper for medicinal use. Such decoctions therefore are not to be thrown away, but to be inspissated with a moderate heat, that they may be kept uncorrupted; for, being afterwards mixed with the distilled water, the virtues of both are thus united, and afford the whole efficacy of the plant. And of this kind are camomile, carduus benedictus, the lesser centaury, germander, ground-pine, mugwort, rosemary, sage, scordium, wormwood, &c. This tribe of herbs, indeed, are exalted by fermentation, so as to afford the better waters; but when their decoctions come afterwards to be inspissated, they either have less, or a different kind of virtue from the natural.

(7.) Acid, bitter, austere, sweet and flat tastes, rarely ascend from plants in distillation, but commonly remain in their extracts, tho' they ascend from camomile, wormwood, and a few more; but the colour of plants is scarce ever raised by distillation, tho' we have a blue colour in the distillation of camomile, and a green one in that of wormwood; but these colours are rather in the oil than in the waters. The saponaceous virtue, consisting in the union of the salt and oil, never rises, but remains in the extracts; and therefore plants endowed with this virtue are not to be thus distilled (a).

(8.) The following vegetables scarce afford any thing of use in their distilled waters; viz. barberry, beet, cherries, colewort, currants, elder-berries, endive, ripe grapes, ladies-mantle, lettuce, the juices of citrons, lemons, oranges, purslain, scorzonera, sorrel, strawberries, and succory. There are also very contrary virtues in the same plant: thus the distilled water of cinnamon, of the first running, is deobstruent, heating, enlivening, stimulating, and good in vomiting; but that of the second running astringent, cooling and nauseous; whilst the decoction remaining in the still is of a dark red colour, opaque, thick, of an austere taste, astringent, coagulating, and strengthening.

PROCESS XVII.

The common distilled water of a recent fermented plant, in the manner of Ludovicus; by an example in rosemary.

THE effects of distillation, digestion, and cohobation, have sufficiently shewn us the action of the fire, limited by the degree of boiling water, in distillation and cohobation; and of a more gentle fire, with water, by digestion. We now proceed to exhibit an elegant and useful way of obtaining the medicinal virtues of plants, very little altered from what they naturally are, tho' rendered more penetrating and more volatile.

(a) See the catalogue of plants in the second process.

1. Take recent rosemary, with the conditions expressed in our first, fifteenth, and sixteenth processes, cut and bruise it, if that seems necessary; put it into a large oak cask, leaving a space empty at the top four inches deep; then take as much water as would, when added, fill the cask to the same height, including the plant, and mix therein about an eighth part of honey if it be cold winter weather, or a twelfth part if it be warm; in the summer the like quantity of coarse unrefined sugar might, to the same purpose, be added instead of the honey; or half an ounce of yeast added for each pint of water will have the effect; but I prefer the honey, used as described: let the proper quantity therefore of honey and water be warmed and poured upon the plant in the cask; let the cask stand upright, and have its wide upper orifice, or bung-hole, loosely covered with a wooden cover; then set it in a wooden chest, to be kept heated by means of a live coal, buried under light ashes, so that the liquor and plant may feel a heat of about eighty degrees, which is afterwards to be constantly kept up by covering the outside with clothes, and a due regulation of the fire, which must therefore be greater and more carefully attended in cold weather; but in the heat of summer little or no fire is required. On the second day, a hissing noise will begin in the liquor, with bubbles, frothing, and a grateful smell of rosemary; the plant now again rising to the surface: this motion is called fermentation. (2.) When this fermentation has continued so long, that the plant which was on the top begins to subside and sink to the bottom, the operation is continued long enough for our purpose, so that now the vessel must be cooled and closely bunged down; for if it should continue longer open in the same warmth, the spirit and oil, now rendered more volatile, would fly off, and the virtues required be lost; so that the matter should be now directly distilled. (3.) Take therefore as much of this plant and its fermented liquor as may fill two thirds of a still, and work carefully from the first: for the liquor, containing much fermenting spirit, easily rarifies with the fire, froths, swells, and hence becomes very apt to boil over. And as all this happens much quicker in this distillation than in the foregoing kinds, we ought here to work slower, especially at the first. (4.) And thus there will come over first a limpid, unctuous, penetrating, odorous, sapid, liquor, all which is to be kept separate; there follows a milky, opaque, turbid liquor, still containing something of the same taste and odour; and at length comes one that is thin, acid, not fragrant, and scarce having any property of the rosemary. There remains in the still an extract, indolent with respect to the rosemary, and retaining most of the substance of the honey. And all these particulars hold, when the fermentation is continued till the plant spontaneously falls to the bottom of the cask; which, with the abovementioned degree of heat, usually happens in five or six days. (5.) This first water, or rather spirit, may be kept for several years, in a close vessel, without changing or growing ropy. It also excellently retains the taste and odour of the plant, tho' a little altered; but if less honey were added, less heat employed, or the fermentation continued only two or three days; then the distilled water of the first running would be white, thick, opaque, unctu-

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'ous, frothy, and perfectly retain the scent and taste of the plant, or much less altered than in the former case; tho' the water will not be so sharp and penetrating. After this is drawn off, a tartish, limpid, inodorous liquor will rise, leaving a remainder behind, that retains much less of the properties of rosemary, than in the preceding process.'

2. There is also in this case always found some oil in the first water, which was not in the former spirit. Again, if the fermentation were to continue only for a day, or a day and an half, the water that first comes over would largely abound with oil. In other respects matters are nearly the same in both; for it is constantly found, that the longer the fermentation was continued, the less oil appears in the distilled water, and therefore what runs first is always clearer and stronger; but upon mixing with common water, the whole immediately becomes milky; whence these waters greatly differ from one another, according as they are differently prepared in the abovementioned respects. When the fermentation is perfectly performed, the first water will be limpid, the second milky, and if a third be forced over by a strong boiling heat long continued, it will prove acid, thin, and limpid, resembling distilled vinegar. The extract in this case will always be the less impregnated with the virtue of the plant employed, the longer the fermentation was continued, or the more perfectly it was performed, and *vice versa*; the oil also, which in the fifteenth and sixteenth processes floated upon the surface of the water, becomes so attenuated when the plant is perfectly fermented before distillation, as entirely to disappear and lye concealed, or subtilly divided in the distilled liquor; which may therefore be called spirit, rather than water. That this is the case appears from hence, that if a large quantity of water be added to the spirit, it presently grows white; which shews that there was oil concealed in it: nay, frequently, little drops of oil, thus regenerated, will float upon the surface of the water.

The use.

1. Hence we learn that this fermentation (when perfectly finished in the proper time required for that purpose, with a large proportion of ferment, and if the whole fermented matter be for some time contained closely bunged down in a cask) affords these waters extremely limpid, hot, aromatic, odorous, sapid, and penetrating, without any sign of their containing an oil; and according as these properties appear more in the water, the native virtues of the plant are more changed; so that at last they can scarce be known; but when the fermentation is perfect, each losing its proper character, they all become nearly alike: whence it is manifest that the particular virtues of vegetables are not exalted or perfected by fermentation; as they were in the preceding process by repeated cohobation; and that the waters by such cohobation are not rendered so spirituous, as by a single fermentation. And this seems to proceed from hence, that in the long continued and active motion of fermentation, the volatile presiding spirit, now freed from the opened parts of the plant, but principally from the attenuated oil, exhales; for the tenacity of the oil was the chief thing that detained and locked the spirit in the plant. But a gentle and moderate fermentation, which does not dissipate the spirit,

The Practice of CHEMISTRY.

spirit, only dissolves the viscous obstacles, admirably quickens these waters, makes them durable, or long preserves them from corruption, dregginess and ropiness; as is excellently observed by that skilful and candid chemist *Daniel Ludovicus*, in his dispensatory accommodated to the present age. And thus the water of *carduus benedictus*, so prepared, is highly commended, where sweating and perspiration are required.

2. Hence the taste and smell of plants, communicated to their distilled waters, principally depend upon their native spirit respectively. But as this spirit is wrapped up in a tenacious oil, when this oil is mixed with the waters it renders them the more odorous and sapid, in the larger quantity it is so mixed. This oil is gradually thinned, made less tenacious, more spirituous, and easier to mix with water, by distillation, digestion, and cohobation in close vessels; but thus the spirit also becomes more volatile and disintangled, so as easily to fly off, unless it is every way very closely confined in the vessels during the distillation; which being performed, highly efficacious waters may be thus prepared. But as fermentation requires a length of time, the admission of the air, and open vessels, it attenuates oils by its motion, so as to mix them with water, and in this form make an inflammable liquor; which cannot happen without a dissipation of the native spirit. It however renders oils miscible with the animal juices, and fit to enter the finest vessels; but always destroys the peculiar virtue of the plant: in the mean time, it proves the medium of conveying stimulating and grateful virtues to the nerves; especially those of the nose, mouth, jaws, throat, stomach, and intestines.

PROCESS XVIII.

The common distilled water per descensum, from a recent plant; by an example in rosemary.

CHEMISTS formerly called that motion of bodies distillation, when, by the assistance of fire, the subject to be changed, and contained in one vessel to which the fire was applied, passes into another joined thereto, whether solids were thus treated or fluids; and this operation with them differed in three respects. For, (1.) the fire raised the matter perpendicularly upwards. (2.) Somewhat obliquely, or laterally, as in distillation by the retort. And, (3.) downwards; the fire being applied above: which last species of distillation they called distillation *per descensum*, which they used in the last age for separating quicksilver from its ore; and which *Paracelsus* from thence transferred to vegetables. Of this kind of distillation we are now to give an example.

1. Let there be procured a sufficiently wide, and deep cylindrical vessel, made of such matter as will neither transmit, drink up, or foul liquors. From the upper rim of this vessel cut an inside groove, fit to receive exactly, and sustain a round plate struck full of holes; which is to sink into the open mouth of the vessel, so far, that the upper surface of the plate be two inches from the rim thereof; then place any recent, green, succulent

culent plant first cut or bruised, upon the plate, so that it may reach up to the rim; then apply a flat cover, which may exactly close the mouth of the vessel, with the assistance of luting to prevent any vapour from exhaling (a). The whole apparatus may be made of iron-plate, if a large quantity of water is required at once; otherwise, for a single experiment one of earth may suffice. Let a little fine ashes be sifted upon the cover, and a few live coals be placed thereon, that the moist parts of the plant may be resolved into vapour; and its juices be liquified so as to fall into the wide part of the vessel below; where being condensed by the cold, they will gradually distil, and collect; if the fire be prudently managed and encreased by degrees. And thus the spirit, water, wax, gum, oil, rosin, as also the saline and saponaceous matter of vegetables, which do not easily rise in the preceding distillations, may be obtained. Care, however, must be had not to make the fire too large, for fear of quite burning up the parts of the subject, tho' indeed a small degree will have but little effect; but if a violent fire be used, all the parts will be confounded together, the oily matter burnt up, the smell and taste of the produce become empyreumatical, smoky, bitter, and nauseous, so as to be scarce fit for internal use, especially if the subject were dry and unctuous. But when succulent vegetables are employed, such as rose-flowers, and prudently treated without burning; the water so prepared will nearly resemble the natural juices, as containing both their saponaceous nature, and peculiar virtues, tho' always a little changed by the fire; whence the expressed juices themselves are not only more agreeable, but more medicinal. Paracelsus, however, by treating guaiacum in this manner, obtained an acid liquor, and a sharp foetid oil, which he recommends both for external and internal uses; whence this operation has been for some time practised in Germany, but is now almost disused, or changed for others more suitable.

PROCESS XIX.

Saline ashes extracted from the calcined remains of the fifteenth, sixteenth, seventeenth, and eighteenth processes; as in the fifth, sixth, ninth, tenth, and eleventh.

1. **I**F the remains of the fifteenth process, that is, both the plant and the liquor left after the distillation, be put into an iron vessel, and evaporated or dried, then committed to an iron pan, and burnt to white ashes over a naked fire, as in the sixth process, a large quantity of salt may be afterwards extracted from these ashes, or the same which the crude plant would have afforded, if burnt before it was distilled; for both the ashes and the salt here produced are perfectly the same as in that case: or if the decoction remaining in the still be taken separate, or, with the addition of all the liquor which the boiled plant affords by expression; and a salt made thereof, as in the fifth process, thus likewise the same ashes and the same salt will be obtained, nearly in the same quantity, as

(a) See Libavius, in

‘ in that process : this distillation therefore does not diminish the matter of the salt.

‘ 2. If the remains of the sixteenth process be treated in the same manner as the preceding ; or if only the decoction, or the decoction with the plant be employed ; the ashes hence obtained will be twice as saline as the precedent, but the salt the same tho’ in double the quantity. And when, as we instanced in the cohobation of baulm, the operation is sixteen times repeated, the decoction will then afford sixteen times more salt ; whence it appears, that the decoction upon cohobation encreases in its saline saponaceous virtue, as the cohobated water does in its volatile spirituous and oily part ; whence we are furnished with a method of exalting the peculiar virtues of plants at pleasure : and hence art, in a very extraordinary instance, may certainly excel and improve upon nature. And at the same time, cohobation will not diminish the matter of the salt in the more fixed part, tho’ ever so often repeated ; provided all putrefaction be prevented in the plant.

‘ 3. But when plants are fermented without sugar or honey, and then distilled according to the seventeenth process ; and the remains come to be calcined after our present method, we shall here again obtain almost the same quantity of the same salt : whence it appears that fermentation, so performed, does not volatilize that matter in vegetables which affords this salt upon calcination. This might appear strange, if we had not before found that the tartar of the most perfectly fermented and subtile wine did not afford a large quantity of fixed salt upon burning. But when the rosemary is fermented along with honey, and the remainder is afterwards reduced to ashes, these ashes will have but little sharpness, nor easily afford an alkaline salt ; for a coal made from honey can scarce by the fire be rendered saline ; but remains somewhat fungous therein, without growing sharp. And the remains of the eighteenth process afford the less salt by burning, the more saponaceous and saline matter came over in the water ; but if very little of this water was afforded, then nearly the same salt will be obtained.’

The use.

1. If all these particulars are well understood, we may hence learn the true effects of these different distillations. And, (1.) they separate the simple elementary water of vegetables. (2.) The spirit contained in this water, as described in our third process. (3.) The volatile oil or sulphur, which when mixed with the water turns it white ; but when collected separate, refuses to mix with water, or gradually disintangles itself from it. In this oil the native spirit principally resides, communicating the smell, taste, and often the particular virtues of the plant thereto. This oil is what I usually call oil of the first order in plants ; being easily and first of all separable from them, as slightly mixed in with their juices, but not strongly fixed thereto ; nor greatly adhering to their solid parts, nor much intangled therewith, but often lodged in particular vessels in many subjects : and when these three are separated from a plant, it afterwards scarce retains any thing of its pristine taste and odour.

odour. (4.) By this means also there is separated a certain thin, volatile, acid liquor, which, being subtilly saline, is not fixed but flies off in the burning, and may therefore be properly called the natural vinegar of the plant. This comes over along with the last water in the distillation of cloves and cinnamon, and even any other the hottest vegetables, after the three former matters are entirely separated.

In that part of the plant which, not being volatile in distillation, remains behind, we find, (1.) a more fixed oil more intricately mixed in the remaining fixed liquor, so that it cannot be raised in distillation, but remains firmly connected with the proper salt of the plant, so as to form a soap; and a large part of this oil is by the force of a naked fire intimately mixed in among the salt of the plant, so as thus to form the fixed alcali: yet this oil, still adhering to its own salt, may be extracted from the plant by boiling in water (*a*). (2.) The oil which is intimately fixed in the elementary earth, and joins the solid frame of the plant together, and which cannot be thence separated by the force of boiling water (*b*). (3.) A very large part of the proper native salt of the plant. (4.) That matter of the plant which is afterwards fixed, and changed into a fixed alkaline salt, by the action of a violent open fire. (5.) Lastly, a large part of the elementary earth which goes to constitute both the fluids and solids; we say, a large part only, because much earth is extracted even from the volatile oils of plants.

PROCESS XX.

The native oil of vegetables by expression; shewn in almonds.

THERE is a certain part in plants, which being either spontaneously fluid, or easily made so by a gentle heat, is called their oil. This oil may become thick by long standing, as we see in the oil of turpentine, which, tho' extremely fluid at first, manifestly thickens by degrees. It may also grow thick with cold, and thus appear knotty like fish-spawn; nay, it may even become solid, as we see in wax; but by what means soever it thus becomes hard, it flows again upon being applied to the fire. This oil, therefore, whenever it becomes liquid, is at the same time unctuous, or exceeding soft and slippery to the touch; tho' it has at the same time a certain tenacity or viscosity in its parts, not found in waters and spirits. Again, these oils are always inflammable, and feed both fire and flame, being themselves disposed to go into flame; a property not found in air, water, or earth; lastly, oil will not intimately mix with water, but when shook therein repels the water from it, collects together, and separates into a distinct liquor; in which respect it differs from spirits. Vegetable oil, therefore, is an unctuous inflammable liquor, that does not mix with water.

This oil is found of many different kinds in plants; the volatile sort which we have seen produced in the distillation of the waters from unctuous vegetables, lodges the presiding spirit, which contains the taste and smell of the

(*a*) See process, 3, and 5.

(*b*) See process, 3, 4.

plant; whence in this oil the particular sensible properties of the plant manifestly reside; which, being once separated, robs the plant of its nature. Thus, if all this oil were totally extracted from cinnamon, mace, cloves or nutmeg, these bodies would remain of their pristine form, so as to be perfectly knowable, tho' they retain nothing of their peculiar properties. For when all this oil is taken away, those spices can no longer be distinguished by the smell or taste; tho' the body of the oil receives not its smell and taste from itself, but entirely from that spirit, which, when present, distinguishes these oils, and, when absent, leaves them scarce distinguishable, and almost of one and the same nature.

Sometimes in certain plants, and particular parts thereof, this oil is collected pure, in little peculiar cells or receptacles; at other times oily particles are mixed with the juices of plants, and so dispersed therein as scarce to appear in the form of oil, but lye concealed in that of soap. But when these latent oily particles associate, or separate from the rest, they immediately appear in the form of oil. Thus the juices of a plant being extracted with water, inspissated, made saponaceous, and dried, it is manifest that they contain oil by their burning (a). On the other hand, a pure oil distils from incisions made in the fir, the pine, and the larch tree. A transverse section being made into the root of master-wort, newly dug up in the winter, we may, by the help of a microscope, perceive little drops of gold-coloured oil, ouzing out from certain vessels on the surface: and the same holds true of a nutmeg, or almond, cut with a warm knife. But we find this oil no where more plentifully than in the cotyledons, or seminal lobes of plants; where it defends the tender embryo from the pernicious effects of unseasonable water, or too great cold; for freezing might probably prove destructive to so fine a structure. This oil, likewise, is in the winter-time found driven towards the bark, by the preceding summer; and being there more drained from its watery moisture, is collected in great abundance, especially in the ever-greens. The oil of vegetables, therefore, chiefly abounds in their more durable parts, in order to defend the other natural and more necessary ones, and is therefore found in such parts, as are farthest removed from the absorbing vessels of the roots, and the nutrimental juice there drawn in from the earth; and thus, more oil is found in ripe linseed, than perhaps in all the other parts of the plant together. Sometimes, also, this oil is collected in such quantity as spontaneously to appear in its proper form, burst its cells, and run out; whence the barks of trees and fruits principally afford it, as we see in pine-apples, juniper-berries, &c. especially in the ever-greens, where the outward bark is often cased over with this oil. The trees in the northern regions, which grow upon the high mountains, exposed to the freezing cold, more particularly afford it; whence it should seem that this oil is highly requisite to defend the life of vegetables, against the freezing cold of winter. We likewise observe that these fat oils chiefly grow and collect in full-grown plants, that soon after seem as it were to sleep, or become aged; for both herbs and trees contain little oil in their young growing state, but are distended with a dilute,

(a) See process 3, and 5.

thin, watery juice. Thus flax, soon after it is first sown, rises in the form of grass, and is merely aqueous; but when come to maturity, it loses its greenness, grows yellow, and now affords a copious oil, especially in its seed: and the same holds true of a young pine, compared with one that is full grown. It is also observed, that the shrubby plants, which have lively roots, gradually contract themselves upon the approach of winter, withhold their juices, perspire but little, receive little nourishment from the earth, nor throw much off into the air; and thus they continue to do in a higher degree, as the winter comes on, till at length they in a manner rest. On the other hand, as the spring approaches, all begins to move again, they take in nourishment and perspire. If these autumnal or winter stations may be called times of sleep, and the summer and vernal periods times of waking, in plants, it will generally appear, that the oils of vegetables are encreased in their sleeping, but their water in their waking. Thus the root of master-wort being perfectly leafless in the winter, and lying hid and unactive in the earth, may be called dormant; but if now dug up, and examined, it will be found rich in oil; but if again dug up in *May*, it appears aqueous, saline, and by no means so oily as before: and the same is observed in trees. Lastly, we see that old trees are oppressed with their own oil, and thence suffocated, thro' the abundance of fat, as the pine, the fir, &c; where this oil appears in the form of a gum, but in others under that of rosin, oil, or balsam. And hence it is that gardeners so frequently complain of the death of trees, obstructed in their bark; which thus die, as animals do, when choaked with their own fat.

The chemist, therefore, who would extract the oils of vegetables should first learn from botany, that there are certain seasons wherein plants abound with water and salt, and then but little with oil; and again, that there are other seasons wherein they principally abound with oil, and but little with water and salt: for whilst new leaves, flowers, and fruit are forming in plants, the motion of the aqueous juices, pregnant with salt, is promoted, and the sluggish oils excluded; but when the leaves begin to wither and fall off, the flowers to shed, or the fruit to ripen, or spontaneously fall off, when perfect, then the oily parts gradually collect together and preside; the more subtle ones being dissipated by the summer's heat: whence builders sell their timber in the midst of winter, that it may be durable, and proof against moisture and rottenness. For all the hardest, most ponderous, and lasting woods are found to abound with a ponderous oil; thus cedar and *lignum vite* contain an exceeding heavy compact and copious oil. Chemists, therefore, must choose their subjects for salt at a certain season, and for oil at a very different one.

The process.

1. The ripe seeds of most vegetables, when they begin to fall and grow dry, contain a copious native oil; these seeds therefore being taken, and somewhat farther dried, are ground into a kind of meal; but if they prove too unctuous for this purpose, let them only be bruised in a stone mortar; by which action alone some of them will yield an oil; such as almonds, pine-nuts, pistachos, &c. Let the meal thus procured be suspended a

while in the vapour of boiling water, and then again be gently dried to open it the more, and fit it the better for yielding its oil by expression: put this meal or paste into strong hempen bags, which are to be close tied up, and place them between two iron plates heated in boiling water, and squeeze the bags in a strong press; and thus the oil being melted by this innocent heat, will sweat and drop thro' the bags into a receiving vessel placed underneath, without *empyreuma*, but almost as it naturally existed in the plant. And by this means may an oil be drawn from the seeds of the least oleaginous plants, such as hemp, flax, lettuce, and numberless other subjects; in which no mortal would have expected such an oil should lye concealed. In the same manner, a copious oil may be expressed from cloves, mace, and nutmegs; tho' the sharp aromatic virtue of these spices will not be found in their expressed oil; for mace and nutmeg, when thus treated, rather afford a mild and very thick balsam, than a hot aromatic oil, such as they yield by distillation. I was formerly surprized that the express'd oil of mustard-seed should be ordered with success in the raging pain of the stone, but my wonder ceased upon finding this oil so sweet, so soft, and mild; whereas that by distillation, from the same seed is so violently sharp and fiery, that to this day I cannot sufficiently wonder at the difference as often as I consider it; for it seems difficult to assign the reason why this expressed oil has not the pungent taste and odour, which are so remarkable in the distilled oil, and why the acrimony of the preceding spirit, which resides in the oil, is not here manifest: and this whether we regard the water, the salt, the spirit itself, or its oil (a).

2. The oil of our present process contains very little salt, tho' it has evidently much of the particular nature of the plant, as our senses inform us; but whilst fresh, it sheaths, blunts and mollifies what is acrimonious in the humours, relaxes the fibres, membranes, vessels and *viscera*, when applied thereto, softens the hardness of the flesh, and cures its crispiness; it mollifies and moistens dead and dry escars, and renders them separable from the sound flesh by the vital actions; it defends the naked parts in wounds, and prevents the dry air from hurting them by desiccation. It also prevents the thin humours from exhaling too much thro' the open mouths of the vessels in wounds, and thus spoiling the extreme vessels; and hence it becomes an excellent remedy for expeditiously healing recent flesh-wounds. It is also accounted a great anodyne, both as it is emollient and relaxing; but these oils have one strange property, whereby, with the heat only of 70 degrees, they presently degenerate, without any foreign body being mixed with them, and thus become thin, sharp, bitter, rancid, yellow, corrosive, and inflammatory; whereas they were before thick, mild, sweet, almost insipid, white, anodyne, and relaxing. And these surprizing changes happen in a few days in the summer's heat. Is it not strange that fresh drawn oil of almonds should prove healing and suppling to the parched rough mouth and jaws in the

(a) Let the expressed oils be distilled, and the remains or pressings; for does not distillation increase and raise only the more penetrating, volatile, and pungent oil, and spirit of plants?

quinsey, and the same oil in a few days afterwards suddenly inflame the jaws of a person in health? And the sweeter it was when fresh, the sharper it proves when old and rancid. Hence almonds, walnuts, and pistachos become exceeding nauseous, when rancid, and apt to occasion a sudden quinsey in the throat, and excite a fever, thro' the burning effect they have upon the mouth, throat, stomach, and intestines. Physicians, therefore, should be cautious, when they order oil of almonds in acute distempers, that it be fresh drawn, (from almonds that were not rancid) and, in the heat of summer, not kept above twenty-four hours. The same thing is also found in butter, animal fat, bacon, marrow, and the more perfect oils hereof: all which, tho' innocent when fresh, become highly nauseous by standing unsalted in a hot air, where they turn yellow, blue, or green, become rank, corrosive, and easily poisonous in the plague. Thus a great acrimony is sometimes found in cheese that has been long kept, whereby I have seen the whole mouth violently inflamed. Whence we may easily conceive what effects it might have upon the *viscera*. It is an obvious experiment, that oil, by boiling, will soon turn yellow, red, black, bitter, sharp, and unwholesome. And this shews us how oils may in six hours time become extremely bitter in the stomach, and, when vomited up, be erroneously taken for the bile; for this matter takes flame at the fire. These observations upon the nature of oil may lead us to understand many particulars in natural, medicinal, pharmaceutical, and culinary history.

PROCESS XXI.

Native oils, ground with water, and the matters that afford them, make a kind of chyle, milk, or emulsion; by an example in almonds.

1. IF the oleaginous substances, mentioned in the preceding process, being prepared so far as is requisite to afford an oil by expression, are ground in a marble mortar with a wooden pestle, and a little water slowly and successively poured upon them in the grinding, that they may thus come into a well wrought paste, they will change into a white mass; which the longer it is so ground, the more uniform it becomes, and the better fitted for this process. 2. Then gradually add more fair warm water, so as to make the whole fluid, and continue the triture without intermission, as before; whereby the liquor floating above the matter, will begin to grow milky and unctuous: let the liquor now rest a little, then pour it off by a gentle inclination of the mortar upon a thin linen strainer, that the finer part may pass thro' into a clean vessel. 3. To the gross part remaining behind in the mortar and in the strainer, again add fresh water, and grind and strain as before, adding this second liquor to the former, and repeat this for several times, till the liquor poured off gradually becomes less white, less thick and unctuous, and at length perfectly aqueous; at which time but a very little of the subject will remain in the mortar, and that chaffy, poor, exhausted, and insoluble in water, tho' assisted by long triture; appearing almost merely terrestrial, without salt, or the

‘ the least signs of oil : whence by this means the parts of vegetables filled
 ‘ with oil are divided into two distinct kinds ; the one dissolvable by water,
 ‘ the other not. And it is very remarkable that the same is performable
 ‘ with the mass remaining in the bags, after the oil was express’d according
 ‘ to the last process ; excepting only, that so much the less white, thick, unctuous
 ‘ liquor will be afforded, as the more oil was forced out, but even
 ‘ after the utmost violence of the press, the remaining matter will still yield
 ‘ a considerable quantity of this milky liquor.

The liquor, thus prepared, resembles in many respects the chyle of animals, which is itself prepared from vegetables in their bodies, by chewing, ruminating, and the action of the stomach, before it is mixed with the bile in the *Duodenum*. The thing appears plain from the white colour, the mild odour, the sweet taste, the thick unctuousness, and the great disposition they both have to turn sour. So likewise, if the liquor thus prepared stand some time in a tall cylindrical vessel, it spontaneously separates into a white, thick, and almost totally oily part, which floats at top, and into a thinner, transparent, bluish liquor, that remains below ; wherein it perfectly resembles milk, as dividing itself into cream and thin milk. Again, if this liquor be kept for some time, in a warm air, it turns sour, and afterwards considerably sharp, tho’ without acquiring the proper rancidness of an express’d oil, as described in the last process ; in which respect also it perfectly agrees with milk, which acquires the like acidity in such an air, without becoming rancid like pure oil : whence this farther remark should be made, that in acute distempers emulsions may be given with greater safety than expressed oils. But I could never, by any art of coagulation I have used, obtain a curd from this liquor as milk affords ; whence there is this difference betwixt the milk of vegetables and animals. The reason of the difference between the expressed oil of the preceding, and the emulsion of the present process, seems chiefly this, that the mealy part in the grinding being constantly in fine particles interposed betwixt the pure oil, the parts of this oil are so broke and separated from one another, that its tenacity being changed, it becomes miscible with water, and thence appears in the form of milk, which also consists of a fat substance dissolved in water ; whereas when a pure oil is obtained by expression, the parts thereof, being in contract with each other, do not admit of water, nor suffer it to be mixed among them. Again, the large quantity of meal, intermixed amongst the oil in the emulsion, causes it to turn sour, not rancid ; and hence appears the reason why the liquor is white ; for whiteness always ensues as often as oil is intimately divided and mixed with water. If oil be poured upon a glass of water, the two liquors will remain separate and transparent ; but if shook briskly together, they will unite in some measure, and during that union the mixture will appear perfectly white ; but if now suffered to rest, the oil collects at the top, the water sinks to the bottom, and the whiteness immediately vanishes : and the same thing frequently happens in animal milk, distilled oleaginous waters, and these emulsions. It is also certain, that the whiteness becomes greater, the larger the quantity of oil ; and, in this case, the liquor sooner grows rancid ; but the less the oil, the less white the liquor, and the sooner it

it turns four. In the summer, emulsions will scarce keep above ten hours, but in the winter longer. To conclude, this method of making emulsions gives light to the action of mastication; for all the foods prepared from corn, abounding with a latent oil, and being ground by the teeth in chewing, and mixed with the *saliva*, the longer they are thus acted upon in the mouth, the nearer they approach to these emulsions, and at length always turn white, when the *saliva*, salt and oil are well ground together. The operation thus begun in the mouth is carried on in the stomach, and more perfected in the intestines, where the matter still retains the same nature; except that new juices are perpetually mixing themselves therewith, and communicating their properties; whereas in our pharmaceutical operation, there is no addition but of water alone. And hence we may understand the artificial distinction between the first chyle, and the milk of animals.

PROCESS XXII.

The native oils of plants, prepared by simple boiling with water.

1. **W**HEN plants, or their more oily parts, have, according to the 20th process, been deprived of all their oil separable by the press, let the remainder, included in a linen bag, be kept for a sufficient time in boiling water, whereby the oil left behind, being dissolved, will float on the surface, and should now be carefully taken off with a ladle, and preserved together. Let this operation be continued so long as any oil, or fat scum rises, and thus all the oil left in the subject after expression will appear, which might also be obtained in the way of emulsion, by the preceding process; and even the water by boiling so long will acquire a milky colour, and an unctuous consistence, and thus shew that much oil still remained behind. 2. But if the subject were prepared, as in the 20th process for obtaining its expressed oil, and boiled in water after the same manner, an incredible quantity of oil may be thus procured. Thus a pound of the best cocoa-nuts being boiled to a pappy consistence, with a gallon of water, the fat collected from them, which when cold appeared like suet, amounted to seven ounces (a). And still what remains after the boiling, being dried, ground, and pressed, usually affords some quantity of oil; of which there therefore seems to be a surprising proportion in seeds. Tho' there are some of a poorer kind which scarce afford any oil by expression or boiling with water; such as beans, peas, lentiles, &c. yet even these being dried, and gently roasted, afford some oil in both ways: and what is thus prepared by boiling retains much of the particular nature of the plant, not considerably changed.

(a) See the experiment as made by Mr. *Hemberg* in the history of the royal academy of Paris, by M. du Hamel, pag. 371, ed. 1701.

The use.

The three preceding experiments being duly made, compared together, and well considered, shew, (1.) that the native oil spontaneously resides in plants, as a natural constituent part thereof. Whence we also learn the origin of the fat in animals, which feed upon vegetables; since vegetables constantly abound with oil, which may be prepared and extracted from them by chewing, ruminating, and the power which the body has of making the chyle. (2.) We hence see the nature and use of this oil in plants. (3.) So likewise we learn the manner, whereby a liquor, extremely like chyle and milk, may be produced from oil and water mixed and ground together in a certain manner, and hence perceive how the human body acts in producing chyle and milk. (4.) Hereby we are orderly led to consider those oils called essential, which will now soon follow. (5.) Physicians acquainted with these particulars will not wonder whence men in health, who use little exercise, should abound in fat, even tho' they often use nothing but vegetable food; since expression and emulsion can so easily extract a large quantity of oil from vegetables not apparently oily. (6.) Hence we see the origin both of chyle and milk; and, (7.) the nature of those principles which constitute them both; viz. the animal juices, consisting of the *saliva*, the fine arterious dew, the mucus of the mouth, jaws, gullet, stomach, and intestines; and again of those aqueous, saponaceous, oily, and spirituous matters, in the liquors enumerated, which may be brought into the form of an emulsion, and expressed from the grosser parts, by the means of mastication, deglutition, the action of the stomach, and the peristaltic motion. (8.) Hence also may easily be derived the physical reason, why the milk of animals, prepared entirely from vegetable and tartish food, is so apt to turn sour, when out of the body. Recent verdant grass, by being long masticated, or ruminated, with a large proportion of *saliva*, begins even in the mouth to assume the form of milk, and promote the production of fat: whence men usually grow fat with bread and water; and cattle with water and grass. (9.) After all this, we must not credit those who pretend by art to extract more oil from plants than nature has given them; for we cannot generate oil by art, but only separate that which before existed in the plant (*a*). Lastly, these oils gained by expression, emulsion, and decoction, are not to be esteemed as pure, simple, and unmixed; for when analysed by distillation, in the way hereafter to be mentioned, they resolve into much water, foot, true essential oil, and earth, as that accurate chemist Dr. *Slare* has observed (*b*). And from hence it seems to proceed, that these oils, procured by expression, decoction, or trituration, so easily change in the air; as consisting of a mixture of so many different things. The oils prepared by coction contain salt, but not so much as decoctions made with water.

(*a*) Compare this with process 23. pag. 65. and pag. 68. §. 2. and process 25. §. 2.

(*b*) See philosophical transactions abridg'd by *Lewth.* vol. 3. p. 361.

PROCESS XXIII.

Distilled, or essential oils, by the alembic; from the recent leaves of savine.

ALL plants are more or less fit for this operation, but chiefly those which are rich in an aromatic virtue, such as we described in our first, fifteenth, and sixteenth processes; and none of these are more proper for our present purpose than those of a high and fragrant odour, and a pungent, hot and grateful taste: but in the present process, which opens the subject of essential oils, we are more particularly concerned with the leaves of plants. These leaves are either the recent ones of ever-greens, or the fading ones of plants that shed their leaves.

The aromatic leaves of ever-greens, such as the *arbor vite*, bay, box, cedar, citron, ivy, juniper, lemon, *marum syriacum*, myrtle, orange, pine, rosemary, savine, sage, thyme, wild-thyme, are almost always full of oil, but chiefly in the autumn, and towards winter; so that the rule and method of working is nearly the same for them all.

But the annual aromatic leaves which die spontaneously, tho' when green prove highly odoriferous and aromatic, are to be gathered for our present purpose at the time of their full growth, or just before they begin to decline from their utmost vigour; for then the aqueous moisture and the salt being dissipated, leave a more tenacious oil and balsam behind: and the principal plants of this kind we enumerated in the catalogue of our first process. Experience has shewn that these leaves, being gathered at the time above mentioned, afford more oil if they are somewhat dried in the shade, and a moderately fanning air, before distillation, than if they were immediately committed to the still, with a watery juice remaining in them; perhaps, because the water being carried off, the oils unite the closer, and come over in their proper form; whilst being divided by the interposition of the water, they indeed impregnate the distilled liquor with their virtue, tho' they do not appear in the form of oil: but care must be had not to use too great a heat in the drying, lest the oil also should fly off. Some leaves, however, are found to contain so large a quantity of a balsamic oil, as to afford it copiously upon distillation; as we see in mint and rosemary. There are also others that dry with difficulty, and lose of their fine spirit which enriches the oil; such as calamint and maudlin-tansy: so that some particulars are always to be excepted from the general rule.

The Process.

1. Take the green leaves, therefore, of any of these plants, which, without bruising, spontaneously and copiously emit their fragrance; put them into a still, whereof they may possess two thirds, and pour on the distilled water of the same plant to the same height; then immediately perform the distillation; and thus baulm, calamint, dill, dittany, fennel, lovage,

* *marum syriacum*, marjoram, maudlin-tansey, mint, origanum, sage, favine,
 * savory, scurvy-grass, southernwood, tansey, thyme, and wild-thyme, all
 * immediately afford their oils. But others require to be long digested, in
 * a vessel exactly closed, together with sea-salt, or the spirit of vitriol, in
 * order to fit them to afford their oil in perfection, and in larger quantity.
 * Thus if the essential oils be required from the leaves of bays, box, *calamus*
 * *aromaticus*, cedar, camomile, citron, fir, hyssop, juniper, lemon, myrtle,
 * orange, or pine, let them be first gently dried, then put into a still so as
 * to fill two thirds thereof; pour on their own distilled water to the same
 * height, and for every pint of the water add half an ounce of sea-salt, or a
 * dram of the oil of vitriol; lute the still perfectly close, and continue the
 * heat up to 90 degrees, for three weeks, before the distillation: but the
 * more tenaciously any leaves retain their oils, the more acid and the longer
 * digestion they require; for acids loosen and resolve these oils, and, perhaps,
 * in some measure encrease them (a), according to the observation of *Boyle*,
 * *Hoffman*, *Homburg*, and *Le Mort*. Now, therefore, proceed to distillation,
 * as in obtaining the water of the fifteenth process, only observing to make
 * the matter boil quick, and the still strong, for thus the oil required
 * will come over with the first water; whereas if the distillation be too slow,
 * the oil will be agitated by a great heat; yet not being able to rise, it will
 * be mixed in among the water and the leaves, and be thus attenuated, and
 * greatly enrich the water, to the diminution of the oil. Let the distillation
 * be continued with this degree of heat, so long as any oil comes over with
 * the water; the receiver being often changed, to discover how long any
 * oil continues to rise: for the distillation should be continued so long as the
 * water has any considerable virtues, as mentioned in the fifteenth and six-
 * teenth processes; for this water is serviceable in procuring new oil.

* 2. In this operation, therefore, the cells and skins containing the oil, be-
 * ing softened by the digestion, and burst by the boiling heat, which sets
 * free, moves, and rarifies the oil, this is consequently liquified, and thrown
 * to the surface of the water, especially if the plant be *European*. And as
 * the oily particles are carried upwards along with the watry, they are to-
 * gether forced into the worm; where being condensed, by the cold, into
 * oil they are thus transmitted into the receiver pure, considerably natural,
 * without any *empyreuma*, and excellently retaining, in a small compass, the
 * odour, taste, and peculiar virtues of the plant; leaving its remainder per-
 * fectly deprived of all the oil by the distillation, and almost without any
 * mark of its own nature: for the oils of box, calamint, and wormwood,
 * are as perfectly distinguishable by their smell and taste, as the plants from
 * whence they were drawn, whilst the plants themselves, from whence all
 * the oil is extracted, cannot afterwards be well distinguished from each
 * other. These oils long retain their virtues without growing rancid, and
 * therefore, with respect to all these properties, the chemists have aptly
 * termed them *essential oils*.

(a) How does this agree with what was delivered under process 22. *The use, ad finem, &c.*

The use.

1. These oils have a certain sharp, heating, inflammatory property, so as to stimulate the nervous fibres, attenuate viscidities, prove grateful to the smell and taste, and quicken the spirits. Their acrimony appears from hence, that if applied to the naked membranes and nerves in wounds, they give an acute pain. We learn they are heating, because, when taken inwardly, they excite a greater heat than almost any other simple body; so that a free use of them will bring on burning fevers, keep them up, and by an encreased and continued use, raise them even to the utmost degree of heat and violence. When externally applied to the skin of an healthy person, so that they cannot be thrown off, they cause an heat, burning, pain, redness, shining, pulsation, and blisters; and if their action be great, even gangrenes: whence it is manifest how high an inflammatory power they have, when imprudently given internally, where coming in contact with the *viscera* and membranes, they may produce the like inflammations, and hence being actuated in the body by the force of circulation, they effectually stimulate the nerves, and may thus excellently attenuate, and intimately divide those viscidities, which, arising from mere inactivity, require to be resolved by a brisker motion. Again, the odoriferous kind, by their sweetness and pleasant taste, prove highly acceptable and refreshing in faintness and torpidity; and all these effects they have not by means of their oily tenacity, but of the subtle spirits, which are lodged in this oil, and contain the proper taste and smell of the plant, according to what we have already often mentioned (a). These oils, therefore, by a prudent medicinal use, afford the noblest remedies against all those distempers wherein the animal, natural, and vital spirits are wanting, or torpid: for instance, in persons afflicted with cold watery disorders, a simple leucophlegmatia, or mucous serosity, proceeding from mere inactivity, without any inflammatory obstruction. Hence also they become serviceable in winter fevers, that are perfectly intermittent, and attended with cold fits; being given whilst the fever is off, and chiefly before the cold fit is expected. A moderate use of them also is serviceable to aged persons, and to the hypochondriacal, whose blood is sluggish and unfit for affording of spirits; whence such persons become indolent, forgetful, heavy, lethargic, and apt to weep like children. In like manner they are serviceable to hysterical women; but where hysterical disorders proceed from a *plethora*, essential oils, tho' in other cases so excellent, prove very prejudicial; and the like is to be understood of apoplectic cases: for tho' these oils are serviceable where the patient is old, and lethargic thro' a want of spirits and activity; yet they prove almost mortal when the disorder proceeds from blood extravasated within the skull, or from an inflammatory fulness, or *plethora*: whence such persons have been often hurt by the use of apoplectic balsams, prepared from these oils, tho' almost every where indiscriminately commended. They are in no distempers more de-

(a) See pages 31, 35, 36, 37.

servedly praised than against flatulencies in the stomach, gripings, and the colic; but here also they must be prudently used, because these disorders may arise from inflammation, spasms occasioned by fulness, and the like causes, wherein such oils are hurtful; tho', on the other hand, excellent, when those disorders proceed from mere coldness, languid circulation, and a cold viscid serosity blocking up the intestines.

2. With regard to the chemical use of our present process, it is hence manifest, (1.) that aromatic plants contain an oil which is volatile with the heat of boiling water; (2.) That this oil principally contains the presiding spirit, which rises together with it, and after distillation remains for several years therein, provided the containing vessel be close stopped; (3.) That plants contain this oil only in one certain quantity, which being drawn out, there remains no more behind; (4.) But if the boiling water in this distillation be saturated with as much salt as it can dissolve, it will then be hotter than mere water, as was shewn in the theoretical part; whence by means of a large quantity of salt, more essential oil may be extracted from a vegetable than by boiling water alone, without it; but it is erroneous to expect by this means more of the spirit wherein the virtue of the oil resides, for the native spirit is separable by the boiling heat of mere water; so that the promises made upon this head are vain (a). (5.) Hence we learn, also, that these oils are more volatile than the saline matter, which, with a stronger fire, rises in a volatile, oily, acid, or alkaline salt, or that which by calcination is changed into fixed alkali. (6.) That the proper virtues of every plant are found more in these oils, than in other of their simple parts; tho' this always with respect to the spirit wrapped up in the oil: for neither the water, the fixed oil, the saponaceous part, nor the salt of the plant contain this peculiar and proper virtue; as by separately examining all the rest, no one could discover from what plant they proceed; whilst the oil alone, by its smell and taste, never fails to indicate the plant it was drawn from: or if these oils should correspond to two different subjects, it is then usual to give them the same name, as in the oil of roses, and *lignum rhodium*, or rose-wood. So likewise the great agreement betwixt the oil of *cassia lignea*, and cinnamon, has occasioned the true cinnamon tree to be called *cassia lignea*, and the other *cassia fistula*. (7.) Lastly, we hence learn what an excellent part plants may lose by boiling.

PROCESS XXIV.

The distilled oils from dry leaves, by the alembic; shewn in mint.

1. **WE** proceed to shew the same experiment upon a dry plant. Take mint therefore that was gathered in a proper season, dried in the shade, and kept for six months; digest and distil it with its own distilled water, as in the preceding process, observing only not to fill the still above half, with the dry leaves; because being thus shrunk, they will swell very

(a) This should be well determined by experiment. It seems to be true.

much

much with the water poured upon them, and so easily burn or boil over. By this means there will rise, thro' the whole time of distillation, a considerable quantity of oil, rich in taste, smell and virtue, and floating upon the distilled water.

2. If all the liquor be expressed from the remainder, and poured upon a fresh parcel of mint, and all the former distilled water be likewise returned after the oil is first separated from it, with the addition also of as much more distilled mint-water, as is necessary, and the whole be digested and distilled as before; this second operation will afford a much larger quantity of oil, and if several times repeated, the more oil will each time be acquired; for by numerous cohobations, the water will become extremely rich and full of oil. It is manifest, that the distilled waters here retain the peculiar virtues of the plants, as was sufficiently shewn in the sixteenth process. We have also sufficiently explained the use of the present under the precedent, or the twenty-third process; to which may likewise be added what we have before said of procuring oil by cohobation.

PROCESS XXV.

The distilled oil of flowers; by an example in lavender.

THE most odoriferous part of plants either resides entirely, or is found in greatest perfection in their flowers. But as it is here sweetest, so it is most perishable, by reason of the delicacy, unstable, and falling nature of the flowers, tho' indeed there are some, as the kinds of lavender, which long preserve their fragrance; but the method of obtaining their oil is nearly the same in all. For which purpose they are to be gathered at that time they are sweetest, which generally happens when their Petals begin to open; let them be gathered whole, with the morning dew upon them, and immediately be committed to the still, whereof they may possess two thirds; a sufficient quantity of the distilled water of the same flower being poured thereon, and as much oil of vitriol as may give a grateful acidity to the whole; then immediately distil as in the preceding process, by which means some oil will appear floating on the water, which is to be collected and kept apart. Let the decoction be express'd from the flowers remaining in the still, and be returned upon a fresh parcel along with the former distilled water, and a little more oil of vitriol; and thus by repeating the operation, a much larger quantity of oil will be now obtained. Repeat the process three times, or more; for the oftner the work is repeated, the more oil will each time be obtained; the decoction each time growing thicker, and the cohobated water stronger, or fuller of oil, which is to be carefully separated after every distillation. And thus the distilled waters also, so often returned, at length become extremely fragrant, like the oils themselves, and rich in medicinal virtue.

The Practice of CHEMISTRY.

- * 2. As this oil is highly odoriferous, and therefore exceeding valuable, so it can only be obtained in a very small quantity, whence chemists have used great endeavours to find a way of encreasing it, without impairing its virtue, and at length observed, that if the flowers were digested in a close vessel for fifteen days or more, with the addition of so much oil of vitriol as might preserve them from putrefaction, they would afford a third part more of an excellent oil; as we see by an example in the precious oil of roses, given in the history of the royal academy of sciences at *Paris* (a). Some of the principal flowers that are fit for this purpose are the following, viz. the flowers of camomile, citron, clove, hyacinth, *July*-flowers, jasmijn, lavender, white lilies, lilies of the valley, lemon, maudlin-tansley, orange, *philadelphus athenai*, roses and tansley.

The use.

These oils, for their excellent fragrance, are valued by great personages, and sold at a high price; whence it is worth while to study them.

PROCESS XXVI.

The distilled oils of seeds; by an example in fennel.

IT has been long observed, that the oil of plants is plentifully lodged in the *cotyledons*, or double *placenta* of their seeds; whence their oil has been long sought, especially in the aromatic kinds; and it has appeared that the more sharp, hot and odorous they were, the more copious and excellent oil they afforded. Yet nature does not constantly follow this rule alone; for tho' sometimes the seed contains this aromatic oil, as in anise, cummin, &c. yet in others the oil is not found in the seed, but in different parts: thus the curious oil of the rose is only found in its flower, and none at all in the seed, or fruit. The orange-tree contains an excellent odoriferous oil in its flower, the rind of its fruit, and its leaves; but not the least signs of any in its seed. The seed indeed has an oil of its own, but nothing like that excellent one we speak of. Thus the seed of the cinnamon-tree affords none of that admirable oil which so richly abounds in its bark, leaves, and wood. Hence no general rule can with certainty be laid down, but recourse must be had to particular experiments for sure information. The best seeds therefore for this purpose we judge to be those of ammi, amomum, angelica, anise, bay, cardamom, both the greater and the less, carraway, chervil, co-riander, cubeb, cummin, dill, fennel, garlic, hedge-mustard, sweet-marjoram, master-wort, juniper, lovage, mustard, onions, origanum, pepper, rocket, rue, smallage, spignel, scurvy-grass, tansley, zedoary.

- * These seeds are to be gathered when perfectly ripe, and then to be dried for three weeks in an open airy place, and afterwards digested in a

(a) See Vol. II. pag. 208.

close vessel, with hot and salted water, for three days; let them afterwards be distilled in the same manner as was directed of waters, only with a stronger fire; otherwise the oil will not ascend so well: and here again salt water being used instead of common, the oil will be raised the better, on account of the greater heat of the liquor, and so become purer.

2. Some of these seeds contain so copious an oil, that rising collectedly, and so running into the worm, it is there suddenly cooled by the water of the worm-tub, and thus coagulates into a solid mass, which blocks up the whole cavity in one cold part; so that no more liquor being able to descend, the vapour of the boiling water, and oil, with a violent force throws off the head of the still, which might prove dangerous to the operator. It is therefore proper to see that the worm, here employed, be sufficiently wide, and not kept too cool; but when the water and the oil are observed thus to stop their running, let the head of the still be immediately taken off with care, and boiling water poured into the worm, in order to dissolve the oil, and drive it out; after which the distillation may again proceed as before. The seeds disposed to afford this coagulating oil are chiefly those of anise, bay, cardamom, carraway, fennel and zedoary; the oils whereof somewhat resemble camphire, which melts with the heat of distillation, and immediately grows solid in the cold; tho' it still continues a pure oil, that in distillation generally blocks up the vessels. And in the hottest countries, aromatic plants are often so far matured, that their oils thus change to camphire.

The use.

Hence again we learn that a copious oil is lodged in the lobes of seeds, and proves rich in the peculiar spirit of the plant, being here safely treasured up for long preserving the tender embryo, afterwards to shoot out in its proper season. Hence also we see that the vital principle may be long preserved by such a balsam, which seems necessary to prevent its being destroyed by the winter's cold, or lest unseasonable warmth, or moisture, should cause it to shoot before the time, and thus expose it to be easily killed; and hence this oil is principally found in the seeds and roots of vegetables. But as there are many seeds, whose distilled oil has no remarkable smell or taste, whilst residing in the seed; we are hence informed, that the spirits of many vegetables escape the cognizance of our senses, whilst yet they actually distinguish the peculiar properties of plants from each other: whence we are taught to attribute somewhat considerable, but not too much, to the sagacity of our senses. Perhaps, the more volatile the spirituous principle is in the oil of seeds, and of the sharper taste, the less time such seeds will retain their growing faculty: and on the other hand, the less active that spiritual principle is, the longer they will remain fit to propagate their species. Certainly, the fragrant aromatic seeds which have an exceeding pungent taste, soon become effete and barren, as we see in the balsamic umbelliferous kind, and the most odoriferous seeds of the *Indies*, which commonly prove sterile with us in *Europe*; such as cardamom, cubeb, zedoary and ginger; whilst,

The Practice of CHEMISTRY.

whilst, on the other hand, the seeds of *cassia*, the humble plant, *senna* and tamarinds long remain perfect: and the same thing is found in the grain kind, which will long preserve their embryos fit for growing. And here it is highly remarkable, that this oil should continue so very long unhurt in dry seeds, under the form of oil, so as by chemical means to be drawn from thence in full virtue; and yet as soon as these seeds begin to swell and sprout with warm water, they should immediately begin to lose of their oil, and become disposed to produce spirit; whence it should seem possible that this oil may be so changed by the moisture of the fertilizing earth, the action of the warm atmosphere, and the saponaceous virtue of the juices both of the earth and seed, as to be dissolved, attenuated, and rendered miscible with water, so as to be driven into the tender vessels of the embryo, thro' the canals of the *radicula* planted in the lobes or placenta, and thus feed the tender plant with these spirits; and by communicating its own particular nature to the nutrimental juices, impregnate the whole, and produce the species. For seeds once moistened to such a degree as to give signs of vital motion, cannot afterwards be well preserved fit for propagation.

PROCESS XXVII.

The distilled oil of Indian cloves.

THIS *Indian* spice is very extraordinary; the greater sort bears its seed nearly on the top; and the lesser, which is without seed, is so rich in a sharp balsamic oil, that when perfect, and a little heated, it spontaneously yields one that is highly odoriferous and corrosive, barely by the pressure of the finger, or the prick of a needle. And it is incredible what a large proportion of oil these cloves contain, when they first come to us from the *Indies*, and are taken from the middle of the bags, and immediately examined; so that there is scarce any thing comparable to them in respect of aromatic oil. Let a parcel of these, therefore, be chose perfect, and commit them entire to twelve times their own weight of water, and immediately distil them briskly by the alembic and worm: there will come over a milky, thick, turbid water, and at the same time a large quantity of gold-coloured oil, which falls and collects at the bottom of the water. When two thirds of the water at first poured on are thus come over, change the receiver, and add as much fresh water to the remains as came over in distillation, and work as before; whereby there will be obtained a water somewhat impregnated with the aromatic virtue of the cloves. Keep all the odoriferous waters apart, to be used instead of common water in future distillations of the same oil; there will now remain at the bottom a brown, thick, scentless liquor, of an acid and somewhat austere taste, but without any of the former virtue of the cloves, tho' these remains of the subject so far retain their pristine form and colour, as, when half dried, easily to pass upon the unwary for genuine: and if mixed with those that have not been robbed of their oil, they again acquire

'acquire their natural smell and taste, by attracting the oil of the rest; so that they cannot afterwards be distinguished from them: in which manner they are often fraudulently adulterated by certain dealers in spice. The oil thus distilled always appears somewhat mucilaginous; if it therefore be required purer at the first operation, instead of common water let salt and water be employed, and the distillation be performed after a previous digestion of two or three weeks; but the remainder, in this case, cannot so well be examined.'

The use.

This oil is extremely heating, and even caustic, and therefore affords a very proper and incomparable remedy in cold constitutions, and cold diseases, if prudently used. It is also a noble medicine for raising the languid spirits, being used either internally, or externally; but it is surprising that this noble oil should so soon lose its spirits by standing exposed in a wide glass, in the warm open air, at the same time perfuming the place with its odour, and at length changing to an indolent, viscous, unctuous substance; whereas the spice so long retains this spirit in the violent heat of the hottest country. This oil is also heavier than water, so as always to sink to the bottom thereof, and remain in full virtue under it. The like is scarce to be found in the oils of *Europe*, being principally observed only in the hottest parts of *Asia*, *Africa*, and *America*; and chiefly of the aromatic trees, as clove, cinnamon, *guaiacum*, and *sassafras*. Yet this oil, tho' it be so ponderous, becomes volatile with boiling water, and distils along with the vapour thereof. Lastly, it is remarkable, that the plants abounding with so hot an oil, do not appear alkaline in their remains after distillation, but acid, austere, cold, and considerably fixed, as if it were to detain this oil, which of itself might prove too volatile.

PROCESS XXVIII.

The distilled oil of sassafras-wood.

1. **T**HE lighter odoriferous oily woods, cut in the winter, and brought into shavings, whilst sound and perfect, being strongly distilled with twenty times their own quantity of water, afford a milky liquor, and an oil; which from the *sassafras* of *America* is almost pellucid, and sinks to the bottom of water, tho' the wood that affords it is considerably soft, light, and almost spongy. Let the distillation be continued so long as any oil comes over, or the water continues richly milky; and an austere and acid decoction will remain at the bottom of the still. (2.) If a fresh quantity of the same shavings be distilled along with the former decoction and the water that first came over, more oil will now be obtained, and more again at the third or fourth repetition, or cohobation. (3.) And by this means we obtain the oil from all the woods that afford it with ease, such as fir, pine, and *sassafras*; the two former whereof afford lighter oils, that

float on water, but sassafras an heavy one, that sinks therein. (4.) But the hard and ponderous woods must be thinner shaved, and long digested with salt and water before they are distilled; for by this means these also will afford their oil: of this kind are the *arbor vite*, benjamin, box, cedar, citron, guaiacum, juniper, lemon, orange, rhodium, savine, snake-wood, storax, and other balsam trees, as those which afford the balsams of *Capivi*, *Peru*, *Tolu*, and *Gum elemi*; for the longer these woods are digested in close vessels with salt and water, the easier they afford their essential oils by distillation. (5.) Those trees are fittest for this process, which are fat and yield rosin, balsam, gum, or pitch, especially those which are both ponderous and solid; but those which are light, spongy, and grow in watery places, as the alder, the elder, the lime, the poplar, and the willow, with the like, are unfit for this operation, as scarce affording any essential oil. (6.) The trees fell'd at the time when their juices are in their strongest motion, afford less oil, and not so good; but those cut down in the midst of a frosty winter afford a larger quantity, and a better oil. The wood of young trees, whilst in the vigour of their growth, afford less than those which are old, and past their growth. The ever-greens afford a larger quantity, and a sharper oil, than those trees which shed their leaves; whence the reason is manifest why ponderous woods of a strong texture are required in building.

The use.

Hence we may understand that the ponderosity of woods is principally owing to the ponderous compact oil, which closely binds the other principles together; tho' we do not mean their essential oil alone, but chiefly that fixed kind remaining after distillation; of this we have examples in cedar, guaiacum, and juniper wood. And upon the same cause depends their durability; for the most lasting woods are always the most oily, as appears in box, cedar, oak and olive. Extreme hardness also depends upon the same; for spongy soft woods hold little oil, but box, guaiacum, iron-wood, olive and snake-wood abound therewith. And hence we understand the difference of balsam, turpentine, rosin and pitch, as being owing to a longer or shorter, a greater or a less inspissating heat of the sun. Lastly, we hence understand the nature of rottenness in timber, proceeding from the worm which feeds upon the subtle oil contained in the particular cells thereof; which oil being consumed, the wood afterwards falls into a kind of dust or ashes; or else by lying exposed to an air sometimes hot, sometimes moist, sometimes dry, and sometimes cold, the oil is at length consumed, and only a friable earth left behind.

PROCESS XXIX.

The distilled oil of cinnamon.

WE before observed that a copious oil is collected in the barks of trees, particularly those that are old, and of the ever-green kind, which there appears under the different forms of oil, balsam, camphire, turpentine, gum, tears,

tears, pitch, rosin and gummo-rofin, always containing the native fat of the tree. Hence chemists went upon the distilling of these barks in the same manner as woods, and procured a large proportion of excellent oil from them.

The process.

1. Take a quantity of choise and fresh biting cinnamon, break it only so little as that it may commodiously be received into the still, and distil as in the preceding process; there will first come over a water as white as milk, admirably retaining the scent, taste, and grateful virtue of the cinnamon; and along with this water comes a gold-coloured oil, which sinks to the bottom thereof. Let the distillation be continued so long as this oil and milky liquor comes over; but immediately change the receiver as soon as, with the same degree of fire, a more transparent water succeeds, and continue working till no more oil ascends, and the water comes away perfectly pellucid; observing carefully whether it contains any smell, or taste of the cinnamon. When it ceases to do this, let all the water of the second running, which contains any virtue of the cinnamon, be kept separate, and pour fresh water upon the remains in the still; and immediately, by distilling strongly, there will ascend a light, transparent, thin, scentless water, of an acid, cooling taste, which usually preys upon the copper of the still-head, and thus becomes green, nauseous, emetic, vitriolic, and thence vermifugous; but no longer retains any virtue of the cinnamon, and may therefore be thrown away. There now remains in the still a thickish, turbid, brown-coloured, acid, austere, and astringent decoction; whilst the bark itself so perfectly resembles cinnamon, that, without tasting or smelling it, one might easily mistake it for genuine; especially after having been gently dried. And if it be laid for some time among heaps of good cinnamon, it will recover its virtue from them, by robbing them of theirs in the same proportion. (2.) If the two former waters be carefully separated from their oil, and used along with the remaining decoction instead of common water, in the distillation of fresh cinnamon, a much larger quantity of oil will be obtained, and the water of the first running be now extremely strong, white and oily; and by repeating the operation, and each time separating the oil, it may thus be obtained excellent, and in any quantity at pleasure: but there will constantly come over only one determinate quantity both of the oil and rich water, that can by no art be exceeded. (3.) But because this oil is so valuable as almost to equal gold in price, and yet when distilled in this manner, some dreggy mucilaginous matter always adheres thereto, detains it, and prevents a perfect separation; chemists have endeavoured after a method to prevent it, and have found that if the cinnamon be first digested with salted water, or water rendered very acid with oil of vitriol, as we before observed of cloves, then this oil will be obtained purer by distillation, and may be more elegantly separated; and thus by cohobation with this salted, or acidulated water, and the waters before distilled from the cinnamon, the oil may be obtained perfect, and the water almost equal to the oil in virtue. (4.) But the body of the cinnamon remaining after the operation, as we first described it above, when burnt

to ashes, in an open fire, affords little or no salt; but the decoction, described in the second place, being inspissated, affords a very austere extract; which, when burnt according to the fifth process, affords but little salt, that contains nothing of the virtues peculiar to cinnamon: so that it is a fruitless labour solicitously to collect such a small quantity of salt, and join it with its oil for procuring that extremely dear thing called the essential salt of cinnamon.

The use.

The barks of the fir-tree, guaiacum, juniper, pine, savine, and saffra, are principally adapted to this operation; and something of the like kind may be likewise distilled from cassia, having been first long digested. We learn from this process, thus accurately performed, the vanity of those pretenders to chemistry who boast themselves masters of a particular method of obtaining twice or thrice the quantity of this dear and genuine oil from cinnamon; for there is only one certain quantity thereof elaborated by nature, the whole of which is easily drawn from it in this common manner, nor can a grain more be procured by any art. The spirit contained in this oil is perfectly fiery, and will soon consume the parts of a living human body, like true fire; nor is any thing sharper found in other subjects, as is plain from experiments, whether this oil be externally employed, or used internally; for it immediately heats, stimulates, inflames, and burns to a gangrenous eschar: yet there is nothing in all the *materia medica* found comparable to it for its restorative virtue. And if there be any remedy for the cold mucous serosities of the *uterus*, it is this oil properly applied. This wonderful property has often been observed of it, that if it be genuinely prepared by distillation in the island *Ceylon*, and put up in a large quantity into glasses exactly closed, and preserved for many years in a quiet place, a large part of it is said to be changed into a true salt, soluble in water, and rich in the peculiar virtues of cinnamon; as I have been informed by several credible persons. The excellent Dr. *Stare* says, that one part of this oil kept for twenty years, in a well stoppt glass, turned into pure salt (a). But this does not happen if the oil be negligently kept in the open air, where it loses its spirit, and leaves an indolent mass behind: whence there appears to reside in this spirit a certain power of producing salt from its own sulphur; which is a thing deserving of observation.

PROCESS XXX.

Oils distilled per descensum; shewn in cloves.

HUMAN industry first discovered that plants rich in oil, being agitated by the fire, sweat out their unctuous matter, so that it might be collected; and hence was discovered the art of procuring pitch by the burn-

(a) See Philosophical Transact. abr. Vol. III. pag. 362.

ing of fat trees (a). After this, the more unctuous seeds being bruised and exposed to a gentle fire, thus suffered an oil to run from them, as in the case of almonds. At length, by the same method, the aromatic tribe of plants were in particular made to sweat out their oil; but the oil thus procured, differs entirely in smell, taste, and virtues, from that which is thence expressed according to our twentieth process. But we are to give an example of the thing.

‘ Take therefore the best cloves bruised to an unctuous pulp, and spread
‘ it a quarter of an inch thick upon a close linen, stretched and tied over
‘ the wide mouth of a cylindrical glass vessel, so that it cannot fall into the
‘ cavity thereof: and the deeper this glass, the better it is fitted for the pur-
‘ pose; because a spacious cavity serves best to cool and condense the oily
‘ vapour. Then take a dish made of iron plate, so hollowed with a flat and
‘ round rim, that this rim may exactly rest upon that of the cylindrical glass,
‘ whilst the protuberant part of the dish falls exactly within the mouth of
‘ the glass, the depth of the dish’s cavity in the middle, the third of an
‘ inch. Let this dish be a little squeezed upon the cloves, so as to press
‘ them with its convex part, and the linen that supports them a little within
‘ the mouth of the glass; when this is done, fill the cavity of the dish
‘ with clean ashes, and place a few live coals at the top, the heat whereof
‘ passing thro’ the ashes will liquify the oil, and agitate the native water of
‘ the cloves, whereby they will both be resolved into vapour; which com-
‘ ing into the cavity below, will be condensed upon the sides of the cold
‘ glass, and fall in drops to the bottom, in the form of a sharp water and
‘ oil. The fire being thus prudently continued, nearly all the oil will succe-
‘ sively be driven out; and the work is then finished, when no more is
‘ made to descend by that degree of heat: but beware of putting on too
‘ much fire, because this would render the produce empyreumatic. On the
‘ other hand, if the heat be too gentle, scarce any thing will be forced out:
‘ a medium is easily obtained by beginning with a small heat, and rising by
‘ degrees. And thus by repeating the operation, any quantity of oil may
‘ be obtained.’

The use.

This experiment shews the nature and appearance of a proper aromatic oil. The oil so prepared exactly resembles the distilled essential kind, both in taste, smell, and virtue; so as scarce in any respect to be distinguished from it. It is indeed obtained in a less quantity than by distillation with water; but the remainder may be afterwards employed in distillation, or to other purposes, as retaining much of the original virtue. And this method is chiefly of use when such an oil is immediately required, or when we want to exhibit the experiment. In other cases, we rather make choice of distillation: but by the present process, we can expeditiously obtain the oil from the rinds of citrons, lemons, and oranges, and from mace, nutmeg, and other very unctuous substances. And hence we learn what effect this degree

(a) *Vide Alium de Coniferis.*

of fire may have upon oils, as they are naturally contained in vegetables, by liquifying and separating them, so as to make them sweat out almost spontaneously: but when the subjects are too dry to afford this oil commodiously, let them be bruised, then put into a linen cloth, and exposed for some time to the vapour of hot water, that thus they may be opened before they are committed to the operation; for then they will afford more water and more oil, and that less altered, and with greater ease. These oils differ surprisingly from those gained by expression; as being much more aromatic when obtained *per descensum*.

SCHOLIUM.

THIS experimental history of oils, obtained by chemistry from spices, particularly in the way of distillation, as performed from the twentieth to the thirtieth process, contains many extraordinary and useful particulars; the principal whereof we will here briefly enumerate, for the service of chemistry, natural philosophy, and medicine.

1. The entire aromatic virtue of plants is contained in their essential oil alone; which being perfectly extracted, the remaining substance retains not the least sign thereof.

2. This essential oil, again, contains the exceeding subtle, volatile, minute, sharp, and scarce ponderable spirit, which gives the whole virtue to the oil, and which when separated therefrom, leaves nothing particular in the oil: therefore, in these oils, the sulphur is to be carefully distinguished from the spirit, or the resinous part from that which is sharp and fiery. The spirit easily exhales, but the sulphur remains sluggish behind, and gradually thickens, sooner in the air, and slower in a close vessel, thus becoming, from a liquid oil, a gross one, then a balsam, then a more thick and tenacious substance, and at last a brittle rosin; from all which states, it is again recoverable by distillation into a thin liquid oil. Whence many eminent authors have thought that distilled oils are only liquified rosins, and rosins again condensed oils (a). Certainly the sun thus changes oils in plants; for the cedar, the fir, the larch, and the pine weep by incision a liquid and thin oil, which being full of spirit is extremely aromatic, as I have often tried to my surprise; but when this oil comes upon the bark, it begins, with the heat, gradually to lose of its spirit, grow thick, and become a turpentine, not only of a higher consistence, but less rich in spirit than before. This turpentine, when more dried by the farther action of the sun, becomes resinous, losing its spirit more and more, so as at length to prove almost inodorous and insipid. Hence, when it is said, that rosin by being distilled with water, again resolves into an oil, we must understand it of the sulphureous part alone; but not of both the sulphureous and the spirituous; for the spirit does not return, nor is regenerated, but only the fluidity of oil returns. So likewise the aromatic odoriferous tears of benjamin, lacca, mastich, olibanum, and sarcocol, lose much

(a) See *Bohn. diss. chem.* pag. 29, 319, 326.

of their spirit at first contained in their fluid oils; whence the more liquid and recent these are employed, their medicinal effects are always the greater; as on the other hand, they grow perfectly effete with age, and when, at length, all their spirit is gone, the remaining oily matters are scarce longer distinguishable from one another. Hence it seems probable, that the bodies of essential oils are greatly alike, and that the spirits alone make the difference between them. Whether this spirit differs with the specific gravity of the oils I leave to farther enquiry. It must however be carefully observed, that a sharp taste and virtue may depend upon the salt of a plant, tho' in this case, the peculiar characteristic is not owing thereto, but to the spirit of the oil, as we have already shewn above in the history of the alkaline and native salts of plants. Vegetables therefore lose all that is peculiar to them when their oil is extracted.

3. The more pungent odour vegetables have, the more fiery their spirit generally proves; and the more biting when chewed in the mouth, the sharper the spirit of their distilled oil. So likewise they afford the thicker, stronger, and deeper coloured oils, when they are ripest and moderately dried; but when distilled, whilst moist and recent, they afford less of a thinner, more transparent, less heating, but more odoriferous oil: whence, possibly, the spirit itself may arrive gradually at its greatest perfection in the plant: this is certain, that the smell and taste, which proceed from the spirit, are not the strongest, when the plant is young, nor till it has arrived at complete maturity. We must also observe that in certain plants, there seems to be more spirit contained in less oil, than in others, and *vice versa*. When a pound of nutmegs afford an ounce of oil, and twenty-five pounds of *calamus aromaticus* afford only an ounce; this shews that there is not here the same proportion between the quantity of the oil and spirit. There also predominates a certain peculiar acrimony in the spirits that distinguish oils; this acrimony in the oil of cinnamon burns like fire any part of the body it touches, and can scarce be washed off under a long time; and there is an exceedingly pungent spirit in the oils of savory and thyme. Hence, therefore, we find there is a strange disposition in these spirits, which, tho' upon exhaling from the oil, scarce diminish the weight thereof, yet deprive it of its virtue, and leave it ungrateful, thick, terebinthinaceous, and at length resinous. I have searched after the weight of these spirits, but could not discover it.

4. Essential oils are found of different colours, according to the different plants from whence they were distilled. The oil of mint is brown, of lavender yellowish, of cinnamon gold-coloured, of wormwood black-green, of camomile and yarrow blue, of anniseed almost white, and of camphire quite white. Whether this difference depends upon the difference of the spirits, or the oil, or some other third principle, that in some cases rises in distillation, is not certain, and deserves to be enquired into.

5. These oils are sometimes extremely liquid, almost spirituous, or scarce having any tenacity, as we see in the essential oil distilled from the rind of *China* oranges, this being one of the most fluid liquors: and of this kind is the oil of lavender, and even the ponderous oil of saffra-wood. On the contrary, the oils of some other plants are thick; as that of fennel and roses; that

that of anised is still thicker ; and the thickest of all is camphire. But the thick dissolve with a gentle heat, the thicker with one a little greater, and the thickest with a moderate one : whence this proceeds should be farther examined.

6. Again, these oils differ remarkably in their specific gravities ; some being considerably heavier than water, as the oils of cinnamon, cloves, saffra, nutmeg, and perhaps of other aromatic plants that grow within the tropicks, where the violent heat of the sun might otherwise prove scorching to them : for these oils in distillation require a greater fire to raise them, and a shallower still, only one fourth whereof remains empty. Other essential oils are extremely light, as that of lavender, and yet this excess of weight does not make the oils thicker ; for the oil of saffra, as we just now observed, is at once very thin and heavy ; whilst camphire is at the same time extremely thick and light ; so that this must have some other cause. The oil of anised will often remain floating in water, and that distilled from juniper-berries sometimes subside.

7. These essential aromatic oils have an almost inimitable virtue, entirely depending upon the spirit so often mentioned, which is sharp, inflammatory, grateful, refreshing, heating, attenuating, and stimulating to the animal spirits, and nervous fibres ; and by these properties the oils prove serviceable in cold, aged, watery, and phlegmatic constitutions ; and again, in cold intermittents, moist and cold hypochondriacal and hysterical cases, or other diseases proceeding from cold, acid, or aqueous flatulencies in the intestines ; and when prudently used in these cases, they prove generally powerful and safe medicines ; but when indiscreetly applied in distempers attended with violent heat, motion or inflammations, they prove poisonous. The chemists have prudently observed, that these oils act by means of their spirits, which, as lodged in the oil, come to be applied to the parts of the body, so as there to produce their proper actions, which would otherwise easily be lost thro' their extreme volatility ; and when both the oil and the spirit act together, the effect is more gentle, but more lasting. These spirits therefore have and communicate to the oil a certain acrimony, which gives the sensation of fire to the tongue, and presently occasions pain ; and the like effect it shews when applied to the naked nerves : when applied to the external skin, they soon occasion the whole series of an inflammation, and end in a gangrenous eschar. If applied to the lips, or the internal parts of the nose or palate, where the nerves lie bare, it occasions the same, with greater violence, and presently brings on dangerous inflammations. Whence we easily see what effects they may produce upon the mouth, throat, stomach, and intestines, when imprudently exhibited. Hence these oils may justly be called inflammatory ; tho' we before observed there is no better remedy for immediately raising the spirits by their grateful and extraordinary virtue ; which can scarce be explained, for want of general principles, otherwise than by direct experiment. They have not only this refreshing, but also an heating virtue ; for if externally applied, or internally taken, they immediately begin to heat the parts of the body, and presently encrease this heat thus once begun ; but the colder and more languid

guid the body, the less they heat it, and *vice versa*; so that when rubbed upon a dead carcass, they produce no heat at all: whence it is highly dangerous to give them in a burning fever. They also encrease the motion of the nerves by irritation, propelling the spirits, and perhaps agreeably warming them both; and whilst they perform all this, they attenuate and dissolve viscidities, so far as can be done by encreasing the motion of circulation. But we have already enumerated nearly all the virtues, under the twenty-third process, which these oils have in common, excepting that they differ as to their different degrees of acrimony. They have, however, besides these, other virtues no less considerable, and peculiar to each, whereof we have sufficiently spoke under the history of distilled waters, especially those prepared by cohobation. Thus the oils of the life-tree, and of savine, are powerful emmenagogues, where the stoppage of the menstrual discharge arises from a languid circulation. The essential oil of rue is of service in the epilepsy, from a cold relaxed state of the nerves, and likewise in hysterical disorders from a cold cause; that of juniper-berries, in the cold scurvy, and the pains and heaviness thence proceeding; and also in nephritic complaints, from cold obstructions: that of mint, in an almost paralytic weakness of the stomach: that of lavender, in the palsy, vertigo, lethargy, and other cold disorders of the head: the fragrant uninflamatory oil of roses, is a noble reviver of the languid spirits; that of cinnamon very advantageous in a great paucity of spirits, without inflammation, either during the periods of pregnancy, delivery, or immediately afterwards, if at the same time there be no rupture of the vessels: those of wormwood, *carduus benedictus*, the lesser centory, camomile, and tansey, are useful against worms; for which purpose they may be formed into pills with the crumb of bread, and given in a sufficient dose upon an empty stomach; the patient refraining from all kind of aliment for two hours afterwards: those of baulm and lemon-peel, in palpitations of the heart, from cold phlegmatic humours; and those of marjoram, rosemary, and sage, in obstructions and mucous discharges of the uterus from a cold cause.

8. If these oils be strongly ground, for a considerable time, with thrice their own weight of pure and dry sea-salt, so as to divide them well, and then again distilled with water, they become clean, pure and limpid, or freed from their mucilaginous or gummy part, and fitter for keeping, if put up into glass vessels that are not too alkaline, and having close necks well fitted with ground-glass stoppels, and set in a dry cold place: but they lose of their quantity by this rectification; much gross matter remaining behind in the still, unable to ascend by reason of its tenacity. Their virtues also are lessened, which depend upon their spirits, because these remain in the water used in the distillation, and are also dissipated in the water which comes over. This Mr. Homberg shews by a laborious and instructive, tho' dear experiment; for upon distilling such an oil, with fresh water every time, six and twenty times over, he at length obtained only a fourth part thereof; the other three fourths becoming an insipid tenacious substance, whilst the water, four and twenty times cohobated with the oil, was rendered exceeding sharp, aromatic, saline, or spirituous (a).

(a) See du Hamel. *Hist. Acad. Roy.* p. 143.

9. When these pure oils are, without addition, distilled in a glass retort, with a fire carefully and gradually increased, they always exhale some water, and afterwards become more clear, liquid, penetrating, and light; leaving at the bottom of the retort, after the distillation is performed by a strong heat, a black, fixed, spongy, terrestrial matter: and if the operation be thus several times repeated, the greatest part of the oil will be converted into what the chemists call *caput mortuum*. The excellent Mr. Boyle, by this means, reduced a pound of essential oil almost wholly to earth (a).

10. They who have distilled these oils from pure chalk in clean vessels, have found that by cohobating five ounces of oil eight times, upon fifteen ounces of chalk, it afforded only two ounces and one drachm of oil, two drachms and forty-five grains of salt, and half an ounce of a strongly saline water, containing the volatile salt of the oil; according to the observation of Mr. Bourdelin (b).

11. Again, these oils distilled from lime slackt in the air, and afterwards made exceeding dry, are so changed, that a pound of oil being six times distilled, in the way of cohobation upon fresh quantities of lime, with an extreme degree of fire, there came over fifteen ounces and an half of water, and one ounce of oil, according to the observation of Mr. Homberg (c). Hence these oils are found to consist chiefly of elementary water and earth, a little oil, spirit, and salt (d), and therefore grew from the union of those different principles by the action of the fire: whence oil is not a simple elementary body, but a compound of several others. But whether this be really the case, or whether experiments may shew, that these oils are rather transmutable, I do not take upon me to determine.

12. This may be said with greater certainty, that the more excellent of these oils being dissolved in high rectified spirit of wine, digested and distilled with a gentle fire of 100 degrees, give out their native spirit to the spirit of wine, leaving a tenacious oily matter behind; which, being again treated in the same manner with fresh spirit of wine, affords more, and thus at last remains an indolent, scentless, insipid, thick, and tenacious body of oil, perfectly deprived of all its spirit. And if even pure water be long shook with these oils, it takes to itself their spirit, becomes rich therewith, and thus robs the oil of its virtue; so that if the operation be often repeated, it at length leaves the like indolent remainder as the spirit of wine. And hence we are furnished with excellent preparations, and learn that these oils are separable into spirit and oil, a little salt, much water, and much earth; at least, that these are producible from them by distillation. But nothing here seems stranger than that water should remain so tenaciously mixed with these oils, as not to be separated from them by distillation twenty times repeated.

13. Hence again it is confirmed to us by this whole history, (1.) That the peculiar taste and odour of plants wholly reside in their native spirit. (2.) That the taste and odour of distilled aromatic waters is solely owing to

(a) See Boyle Abr. vol. III. p. 356, & seq.

(b) See du Hamel. Hist. Acad. Reg. p. 413.

(c) See du Hamel, ibid. pag. 372.

(d) See Memoir. de l'Acad. Roy. an. 1793. p. 37.

this spirit, as peculiar to each plant. (3.) That essential oils also have their respective characteristics from these spirits alone. (4.) That the volatile oil of plants chiefly serves for detaining these spirits, and the fixed oil for connecting the solid parts together; whence the difference of these two oils is very great. (5.) That both the expressed and distilled oils before explained, are tolerably natural in the plants themselves. And (6.) that the difference of oils is principally owing to their spirits (a).

PROCESS XXXI.

A rob from the remains of the twenty-third, twenty-fourth, twenty-fifth, twenty-sixth, twenty-seventh, twenty-eighth, and twenty-ninth processes.

AFTER the oils are totally extracted from plants by the means of water, without any other addition, there remains behind in the still the same decoction, as if the plants had been boiled for the same space of time with water in another vessel; whence the virtues of the plants, except what resided in the oil and spirit, will remain in these decoctions, unless perhaps they are somewhat changed, by boiling so long in a close vessel; and when the decoctions, remaining after the first distillation, are again employed with the distilled water, and a fresh subject, for obtaining more of the same oil, this second remainder will be stronger than the first, and so after every repetition; thus at length such decoctions become extremely rich; as we have above observed in the history of distilled waters prepared by cohobation, where we endeavoured to shew what these virtues chiefly are. Thus the decoctions remaining upon the distillation of betony, fennel, germander, ground-pine, juniper-berries, tansey, wormwood, and many other vegetables, are fit for medicinal use; as generally retaining a saponaceous, sharp and saline virtue, by means whereof, they may prove considerably serviceable. It is justly observed by Helmont, that the decoction of juniper-berries, remaining after the oil is drawn off, has an excellent purging virtue if taken in a due quantity. And if these rich decoctions be largely diluted with water, and then run hot thro' a woollen strainer, and afterwards evaporated to a rob in a wide vessel over a clear fire, with a degree of heat, a little below that of boiling; their virtues will thus remain perfect for several years, and produce considerable effects in a small dose. And if these robs be farther inspissated and dried, then burnt after the manner of Tacenius, they afford his salt in plenty, but if the decoctions be made perfectly pure by straining, then inspissated to a due consistence, and put into vessels with a little oil poured on the top, they will then afford the native salts of their respective plants, which will now shoot the freer, thro' the absence of the oil.

(a) See Mr. Hensberg's experiment in *de Hamel's history of the royal academy*; and *Hoffman's dissertationes physicae*, pag. 1-63.

The use.

Thus chemistry, almost at the same operation, prepares oils, waters, extracts, native salts, and salts by calcination, for medicinal uses: and these preparations, being again compounded together, afford excellent medicines. Thus if the oil of juniper be properly ground with the native salt of the subject, then exactly mixed with the rob thereof, and at length diluted with the distilled water of the same, we may thus have almost all the active parts of the juniper brought into a little compass, without the terrestrial part which hinders their virtue. And from all this we understand, what different things may be extracted from a vegetable subject, by chemistry; and how far one promotes, or hinders the production of another.

PROCESS XXXII.

The distilled water, vinegar, spirit, two kinds of oil, coal and ashes from guaiacum wood, distilled by the retort, without addition.

THE plants, hitherto chemically examined, seem referable to two distinct classes; the first whereof contains those which by a dry distillation, besides their other volatile parts, afford a volatile, acid, oily salt; and the second class those, which, when treated in the same manner, besides their volatile parts, afford a volatile, alkaline, oily salt; but so that both classes afford more or less in very different degrees, according to the difference of the several plants in each class. We now proceed to give an example of both; and begin with the acid class, by an example in guaiacum.

1. Fill a clean glass retort, almost up to its neck, with the small fine chips of the best, green, close, ponderous and fresh guaiacum, with care to prevent any of it from falling thro' the neck into the receiver. Set the retort in a sand furnace, apply a very large receiver, and lute the juncture close with a luting of linseed-meal. Distil first with a degree of heat not exceeding that of boiling water, and continue this carefully so long as any moisture will be thereby driven from the wood. A liquid, tart, and sharply odorous water will thus come over, which is to be poured out, and kept apart. The receiver being now again luted on, encrease the fire by slow degrees; and again, a considerably limpid, but somewhat more acid, unctuous, and redish liquor will come over, which must carefully be urged with the same degree of heat, so long as it rises. This also may be kept separate, as being considerably strong, odorous and smelling almost perfectly like red herrings. The fire, being now raised and kept up, drives over a red, unctuous, and highly acid liquor, together with a red oil floating in a considerable quantity therein: at length encrease the fire to the utmost, that the bottom of the iron pot may begin to be red hot; there will now ascend a smoke, and a thick, black, viscid oil, that sinks to the bottom of the former liquor. And if this fire be

continued

continued as strong as the glass will endure without melting, the same fume will constantly continue to rise, how long soever the fire be kept up. In the last place apply live coals upon the sand, all around, and above the retort, which is called a fire of suppression, and keep this up also for some time till no more oil comes over; tho' the fume will still remain in the receiver. Now suffer all to cool spontaneously, and by this last extremity of the fire, a little very thick, black, and ponderous oil, like pitch, will be driven over.

2. Make a little filter of cap-paper, put it into a glass funnel, and pour therein the water that first came over without any oil, that the strainer being thus well moistened may transmit this pure water of the guaiacum, which is to be kept separate. This water will be tartish, limpid, and penetrating, but have little of the smell or taste of the guaiacum; but a somewhat burnt odour, a little resembling that of smok'd herrings. Then put the second water into the same filtre, and this will come thro' a little redish, transparent, but more acid, and smelling stronger of smok'd herrings; so as to prove somewhat empyreumatic, and much sharper than the former. And if any oil were lodged in this second water, it will remain in the filtre; which, having been moistened by the preceding liquor, will not permit the oil to pass. Into the same filtre pour likewise the vinegar, and third spirit, together with its light oil; the vinegar will immediately pass thro' red, pellucid, sharp, acid and empyreumatical, but leave its oil behind floating upon the liquor in the filtre: for which purpose the filtre must always be kept filling up with more of the oily liquor, to prevent the oil from ever touching the lower part of the paper; for thus nothing of the oil will come thro' with the acid liquor. When now nearly all the liquor is come thro', immediately remove the funnel with the filtre to another glass, before the oil begins to sink thro' the paper; which would happen when the paper begins to grow dry. At this time, therefore, the light and thin oil may be poured out of the filtre, into a vessel apart.

3. Pour the oil which came over last, along with its highly acid, foetid, and unctuous liquor, into the same filtre, whilst it remains still wet with the former liquor: there will now come thro' a red, acid, transparent fluid, and a gross, black, pitchy, ponderous oil remain in the paper; this also is to be poured out and kept separate.

4. If these acid liquors be preserved in clean glasses, they deposite at the sides and bottom thereof a small oily crust, which gradually encreases, whereby the liquor gradually becomes less unctuous; whence it appears that this distilled vinegar is a compound of water, acid, and oil, and may therefore properly be called a volatile acid, oily, saponaceous salt. If this acid liquor, when become perfectly limpid, and affording no more visible oil, be poured upon clean chalk, it effervesces therewith, deposite its acid in the chalk, and becomes a water that immediately throws the oil, before latent in it, to the surface, in a visible form. Or if the same liquor be again distilled with a gentle fire, in a clean vessel, it also presently manifests its latent oil, and separates it from itself, and thus becomes a pure and clear acid liquor.

The Practice of CHEMISTRY.

5. If the oils be required in greater perfection, let a quantity of them be collected, and distilled from boiling water; whereby the purer part will be raised, and the grosser left behind: and by often repeating this operation, these oils gradually come nearer to the perfection of the essential kind, and by losing their more unactive and terrestrial part, become liquid, bright, beautifully red, penetrating, pure, thin, and not foetid.

6. When thus all that is volatile has been driven over from the subject by the violent and long continued action of the fire, extremely black, light, insipid, almost inodorous, and very brittle shavings remain in the retort, being the coal mentioned by *Helmont*, which can never, by the most continued force of fire, be calcined into white ashes, whilst the vessel remains close, but always continues black, and therefore inflammable; because this blackness is the fixed oil tenaciously adhering to the earth, and subtilly extended upon its surface; whence the coal becomes apt to take fire, and burn so long as this oil remains unconsumed. For if these black chips be now put into a large open pan, and a small live coal be thrown into the middle of them, they will immediately burn and flame all over, till the whole blackness be ignited, after which the subject presently falls into white ashes; so that in a short space the whole body of the shavings may, by means of the smallest spark, be perfectly converted to ashes. Nor could the wood itself be so easily, and so readily fired with a small spark, unless by a like preparation it were first brought to a coal, and then broke to powder. The white ashes thus obtained from *guaiacum* are insipid, and inodorous, and almost without salt; tho' if the wood were recent, they prove considerably rich in alkaline salt.

The use.

There are many remarkable things to be learnt from this experiment, with regard to chemical, philosophical, and medicinal history.

1. And first we hence learn the nature of that primary smoky vapour, which exhales from green wood laid upon the fire, before the wood begins to grow black, take flame, or ignite. For thus there exhales an acid, acrimonious water, offensive to the eyes, and capable of penetrating and preserving such animal flesh as is suspended in the chimney where this vapour rises: and a liquor extremely like it is collected at both ends of a long piece of green wood, laid with its middle upon the fire; which thus drives out a considerable quantity of a tartish water, with a hissing noise.

2. We hence learn the nature of the first smoky vapour, which arises from dry wood, when applied to the fire, or from green wood after the former liquor is driven off, tho' before the wood begins to ignite or burn; for this smoke is thicker, more acrimonious, acid, and ponderous than the former, containing more acid salt, and beginning to grow somewhat black; whence it proves much more offensive to the eyes, and more strongly penetrates, preserves, and cures the flesh, or fish, suspended in it, in some measure tinging them quite thro' of a redish colour; whence it carries up with it some part of the first oil from the wood.

3. Hence

3. Hence again we learn the nature of that black, gross, and keen smoke, which rises from wood thrown upon live coals, a little before it bursts out into flame; for this smoke contains a very sharp, fixed, and copious acid salt, together with the first, second, and third pitchy oil of our process, all compounded and mixed together; which makes a vapour intolerably pungent to the eyes: and this also penetrates the bodies exposed thereto, preserves them by its acid oily salt, alters them farther, and gives them a different smell and taste. This smoke also contains the matter of foot.

4. Hence again we learn, that these vegetable substances afford a water, containing an acid, oily, and volatile salt, which in this state has highly penetrating, aperitive, attenuating, healing, detergent, saponaceous virtues, so as to prove antiscorbutic, diuretic, diaphoretic, and sudorific; especially after being well purified and rectified. It is also proper for external use.

5. Who could have expected that simple elementary water should remain, for so many years, in a hard, and dry form, fixed in the body of wood, or its other principles. I have sometimes distilled, by the retort, the chips of guaiacum, kept for many years in the open air, and thus become dry like sand, and poured the acid aqueous liquor collected together, considerably pure upon chalk or fixed alkali; which easily absorbed all its acidity, and turned it to a pure and copious water, excepting a certain strong scent that remained therein. This water, which at first grew to the wood in *America*; and remained united with it so many years, in an exceeding dry and ponderous state, thus at length recovered its native form of water. Whence we clearly see, that water may remain a long time surprizingly united in bodies, where it would not easily be suspected, and prove the principal cause of their hardness; for as soon as this water is by the fire separated from the other parts of the wood, they presently become friable, soft, and loose; tho' a little before, whilst the water remained in them, they were almost as hard as iron.

6. Hence we see, that a certain mixture of different principles may, by their proportion, form bodies extremely different from those principles.

7. We are hence farther taught, that water, acid salt, spirit, oils, and earth, may be so intimately, secretly, and firmly united, and mixed together by nature, in the production of plants, as not only to remain thus mixed for several ages, as we see in cedar, guaiacum, juniper, &c. but also to ascend together in distillation. Nay, that even water is contained in oil, and oil in water, without affording the least signs of their being there, as we clearly perceive.

8. We see that the more fixed oil in vegetables, after all the volatile part is perfectly driven over, remains united with that earth and matter, which turns to a fixed alkali by an open calcination. And that this oil cannot be driven off, or separated by any force of fire in a close vessel, wherein it always retains its black colour, nor affords any signs of an unctuous substance, but appears greatly exhausted. This oil, we find, is subtilly spread over the earth and fixed salt, whence it takes fire so easily with the least spark, and propagates it over its whole surface by the help of the air; that this oil does not afford a very smoky fire, tho' it smells strong, and somewhat aromatic,

matic and balsamic; and that this small quantity of oil, so long as it continues, hinders the salt from being yielded by the coal: but as soon as this oil is consumed by the air and fire, the salt immediately shews itself, and remains in the white ashes. All these particulars, when duly considered, will shew what a wood coal is, and why the black powder of it has such strange and unexpected effects in chemical operations when mixed with bodies, especially sulphureous ones, intended to be changed. The fixed alcali of coal is slowly generated, and not without the utmost violence of the fire in the open air, after all the inflammable matter is consumed; whilst the last oil is so firmly detained by the fixed matter of the plant, as not to be separated by the fire alone, or without the assistance of the air. Distillation therefore, performed in close vessels, extracts these volatile parts from vegetables, viz. a water, a spirit, an acid salt, two kinds of oil, and in all these much earth; but leaves behind the following fixed matters, viz. the fixed oil of the coal, a matter convertible into fixed alcali by fire in the open air, and lastly, the elementary earth: whence we understand the power of the air and fire, acting together upon vegetables.

9. This experiment is universal, or holds in all trees, shrubs, and most herbs, which, when thus treated, afford all these fixed and volatile parts; for they all contain a volatile acid salt, but the matter which affords the saline alcali is fixed. The recent cuttings of the vine, pruned in the beginning of *March*, afford a copious acid by such distillation; and the calcined coal plenty of fixed alcali.

PROCESS XXXIII.

A water, spirit, volatile alkaline salt, oil and coal, from mustard seed, distilled by the retort.

IT is well known that there are herbs, and certain parts thereof, which, when a little bruised, or scraped, exhale so pungent a vapour, as when received by the nostrils to cause sneezing, or touching the eyes to make them water, and at the same time afford a very pungent smell, as we remarkably see in the bulbous roots of garlic, hyacinth, leeks, *Narcissus*, onions, and squills. Some roots also have the same property as those of horse-radish, both the white and the black, and both the species of water-radish, the seeds of hedge-mustard, mustard, radish, rocket, scurvy-grass and treacle-mustard, and a large number of entire plants, particularly arum, asphodel, bryony, cabbage, camomile, celandine, cherlock, clary, *cneoron*, cresses, *datyra*, dittander, euphorbium, garlic, hedge-mustard, henbane, hyacinth, *lycopersicum*, *melongena*, mustard, onions, *orchides*, pepperwort, poppy, ranunculus's, rocket, sauce-alone, scordium, scurvy-grass, *sempervivum acre*, spurge, tobacco, *thapsia*, treacle-mustard, wild cucumber, &c. for the success of the experiment is nearly the same in all these, and in most of the virulent and caustic plants.

1. Fill

1. Fill a glass retort almost up to the neck with the ripe seed of common mustard; apply a clean and large glass receiver thereto, lute the juncture exactly, and distil, by degrees of heat, in sand: there will first come over an unctuous and yellow liquor, which, being collected apart, is sharp and transparent. Let the fire be now augmented, and there will rise a spirit like the former, but yellower, and along with it a light and very fat oil, which again being collected separate, proves extremely pungent. The empty receiver being again applied, and the fire increased below, and a fire of suppression made above, there ascends a copious black oil, and at the same time a volatile, oily, alkaline salt sticks in grains to the sides of the receiver, as is usual in the distillation of hartshorn. And if this degree of fire be long kept up in its greatest strength, some whitish fume will always continue to rise; and at length a very black, light, bitter, saline mass will remain at the bottom of the retort, as if made by melting of the seed. (2.) If the first and second spirit be again distilled with a gentle fire in a fresh vessel, it affords a pellucid pungent spirit, considerably like the spirit of hartshorn, and having nearly the same uses; leaving a fetid oily water behind. (3.) If the oil be poured off clear from the liquor that ascended last, and from the salt, and the salt adhering to the sides of the glass be washed down with the rectified spirit just now described, a liquor will be obtained saturated with volatile, alkaline salt, and that makes a strong effervescence with acids; and if distilled with a gentle fire in a tall vessel, it affords, by rectification, a pure volatile salt, like that of hartshorn. (4.) All the oils, thus procured, have a fetid, empyreumatic smell, but by rectification become purer, and more grateful; being thus resolved into a copious earth, and an oil that is always finer. (5.) What remains in the retort after distillation seems a true coal, which, however, being reduced to a dry powder, remains somewhat unctuous; nor does it take fire upon receiving a small spark, as the coal of guaiacum did, from which it therefore differs in this respect; but when burnt in an open fire, it leaves a little earth behind, that, so far as I have tried, scarce affords any fixed salt: but I have been very credibly informed that this coal of mustard-seed, when collected in a large quantity, and ground to powder, and long distilled with a strong fire, in an earthen coated retort, thus at length afforded true phosphorus, like that of urine.

The use.

1. All these remarkable particulars, when compared with what we shall hereafter see, in the analytical history of animals, will clearly shew that this kind of plant, and those above set down, correspond with animal substances in this chemical analysis; so that if any, there is at most but little difference between them, as to their productions, except that the parts of animals, perhaps, afford a little more water without oil; tho' this also might probably happen in mustard-seed, when analysed green. Thus much is certain, that mustard-seed, when sown, does, by attracting the juice of the earth, produce a plant, which so disposes the matter of the vegetable, as to be

changed into a volatile alkaline salt, by the force of fire; whence this salt is not so peculiar to animals, as not also to obtain in certain vegetables: and even without fire this alkaline salt appears more in mustard, than in urine, tho' urine be the most alkaline of all the animal juices. For I never found any human urine that would make an effervescence upon mixing with acids; but on the other hand, have found that good mustard-seed, being barely bruised, would make an effervescence with strong vinegar poured upon it. Hence, therefore, a true volatile, alkaline, oily salt may be produced from plants, without any previous putrefaction, and barely from crude natural and recent plants, whether they grow on dunghills, as hedge-mustard, mustard, rocket; or in water, as cresses, horse-radish, and scurvy-grass: tho' one would not easily expect a volatile alkaline salt should proceed from water.

2. Hence physicians may know with certainty where the use of these herbs is wholesom to the body; for they prove excellent when prudently given in distempers attended with an indolent, watery, or cold phlegmatic humour, no way saline; where acid humours are lodged in the first passages; where the bile is sluggish, and where no alkaline, fetid, or oily putrid matter is lodged; but the body remains cold, torpid, and swelled all over: as on the other hand, they prove hurtful where the body is hot and feverish, the bile sharp, the juices putrid, the parts inflamed or wasted; or where the putrid scurvy abounds. And it were highly useful to take a view of the several plants as they are distributed into these two classes; the one affording an acid, and the other an alkaline salt.

PROCESS XXXIV.

The separation of the oils joined with the other principles in distillation; or their depuration, conservation, and conversion into balsam and rosin.

1. **O**ILS should be separated pure from all other matters, in order to their being justly examined and preserved, and to shew what befalls them in keeping. (1.) This separation is usually performed, first by the filtre: thus, cut a piece of filtering paper into the form of a conical bag, and fit it into a clean glass funnel, standing in the neck of a glass vessel; then moistning the paper well by pouring clean warm water upon it, pour in the mixture of water, spirit, and oil; the water, spirit, and the salt dissolved therein will soon pass thro', and leave the oil behind. Continue to pour in more of the mixture, till all be filtered; with care to prevent the oil from remaining alone in the filtre, by continually pouring on more of the mixture before all the former water is run through; by which means the oil alone will be found in the filtre, and the water escape. Then let this oil be immediately poured out of the filtre into a glass, and kept separate. But, as much of the oil here sticks to the paper, the chemists have found another method of separation for the dearer oils. (2.) Let a glass be procured with a long cylindrical neck, ending in a wide orifice;

orifice; heat this glass, and pour the water, with its rich oil that floats on the top, into it, till the glass be full to the very top; then suffer it to rest, and all the oil will rise to the neck, whilst the water remains below: then pour off all the oil, if possible, into another glass, by gently inclining the vessel; but if all the oil does not thus come away, pour as much hot water into the neck as there was oil poured off; which water, sinking below the oil, will raise all the oil upwards into the neck of the glass, from whence it may again be poured off pure. And thus by repeating the operation, all the oil collected in the neck may be thus separated, even to a few drops, by the means of heat, a proper agitation, and the filling up of the vessel. (3.) The same end is obtained by means of a glass called the separating-glass, which is a bellied glass that rises with a narrow neck, but descends in a conical tube open at the end; the mixture being poured into this glass, the oil will rise together at the top, after which the lower orifice being opened, the water first runs out. When the oil begins to come into the narrow stem, the passage should be immediately stopped; and now more of the mixture being poured in at the top, the whole oil by degrees is collected, and the water let go; the oil at length thus remaining alone in the glass. (4.) But if the oil be so ponderous as to sink in the water, when the mixture is thus poured into the separating-glass, the oil will fall into the slender shank, and the water float above; so that after being suffered to rest, the oil is first transmitted below, till the water begins to come into the narrow part; and thus again the oil is obtained separate from the water. (5.) Lastly, when any water still continues to float upon these precious and ponderous oils, it ought to be taken off; otherwise it would render them rosy; the way to take it off is by a wreath of filtering paper, brought to a sharp point, then dipped in water, so as to grow moist therein; when being squeezed dry, and the point applied to the water floating on the surface of the oil, it attracts the water to itself, and leaves the oil pure.

The use.

1. The oils thus separated are to be put up in small and clean glasses, exactly fitted with glass stoppels, then set in a cold dry place, and opened as little as possible; lest the spirit, which gives the virtue and value to the oil, should exhale. And if a little perfect alcohol be mixed with most of these oils, they hence become thinner and fitter for use and keeping, and are thus prevented from growing so thick afterwards as not to drop from the lip of the glass. It also prevents these oils from growing mucilaginous, or rancid, as they might otherwise do; and even recovers them when they begin to corrupt.

2. But by long keeping, these oils acquire the thickness of a balsam, and at last harden into a kind of rosin; and this change is easily occasioned, if the presiding spirit exhale, either by opening the containing glass too often, or leaving it not well stopped, especially in a hot and dry place; but soonest of all, if the glass be left open, for then they become real rosins; whence I

have sometimes suspected that this spirit is what keeps the oils fluid. I once included an extremely pure distilled oil in a glass, and having occasion for it a year after, I viewed it, and was surprized to find it thick; when using another in its stead, and setting the former by again, it in three or four years time became as thick as turpentine: and hence it is that bodies, dipped in distilled oil of turpentine, and then suspended in the air, where no dust comes at them, acquire a transparent resinous case, wherein they are excellently preserved for a very long time unaltered.

3. By this means therefore the proper spirits of vegetables being freed from their gross bodies, and detained in their tenacious sulphur, may be long preserved for the necessary uses; and being thus reduced to a small bulk, be carried into foreign countries without loss of their virtue; so that instead of a hundred weight of cinnamon, a little bottle of its oil, containing all its virtues, so far as they depend on its native spirit, may, without incumbrance, be kept or exported in its stead. And this artificial method seems extremely natural, so as but little to alter or impair the particular medicinal virtues of plants, which it thus collects together, and renders extremely durable; so that were it only for this invention, and its uses, chemistry might sufficiently recommend itself to physicians.

4. But as most of the essential oils are very dear, it has been usual to adulterate them, first by putting bruised almonds into the still, whereby the oil of the almonds, coming to rise with the boiling heat, mixes itself with the essential oils, and increases their quantity. Others practise this fallacy, by adding bruised poppy-seeds in the like manner (*a*). Others knowing that these rich essential oils will perfectly dissolve in highly rectified spirit of wine, and thence become the stronger, adulterate them therewith, without lessening but exalting their virtues, whilst they gain the difference between the price of the two by this artifice. But the former cheat is discovered by the admixture of hot water, which easily separates the lighter oil from the heavier aromatic kind; the one thus rising to the top, and the other sinking to the bottom; or again, by the admixture of pure spirit of wine, which unites with the essential oil, and not with the other more insipid one: and the latter fallacy is detected by mixing the adulterated oil with water; for thus the mixture growing white, this will separate the oil from the spirit of wine, and shew nearly in what proportion the oil was adulterated therewith.

P R O C E S S XXXV.

The vinegar, spirit, two kinds of oil, rosin and colophony, from turpentine, distilled by the retort.

WE have before seen, that the native oils of plants are neither simple bodies, nor of a very unalterable nature; and some of the preceding

(*a*) There seems to be some confusion throughout this process, and its uses, arising from mixing together two different considerations of *essential oils*, and that of oils distilled by the retort: will almonds, or poppy-seeds, yield any considerable quantity of oil, by distillation with water?

experiments have discovered their various principles, and the new productions they afford upon being changed. It seems therefore necessary, that we farther proceed to examine those oils spontaneously produced by nature from the bodies of plants, and collected on their outside, under the name of balsam or turpentine.

1. Take a clean new glass retort with a wide neck, and cut it off short, so that the mouth may remain large and capacious, which is a principal requisite in this operation; then heat pure native turpentine in an earthen vessel, having a lip to pour out at, by putting the vessel into scalding hot water, till the turpentine grows fluid like water; then pour this melted turpentine hot in at the wide mouth of the retort, which is first to be strongly heated to prevent its cracking as the turpentine is poured in. Let two thirds of the retort be thus filled, and leave the other third empty; then hold the retort, so filled, with its neck erect, till the turpentine shall have run quite down the neck into the belly, if any of it happen to stick to the neck in the pouring; otherwise this gross turpentine would run down into the receiver in the distillation, and foul the liquor that first comes over: now place the retort in a sand-furnace, and lute on a clean receiver. (2.) Make a fire that may heat the sand to about 100 degrees, and carefully keep it at this height, so long as it drives over any liquor; by which means a thin limpid fluid, resembling water, will come over, and fall to the bottom of the receiver, whilst another limpid, thin, and oily liquor floats upon it. When nothing more rises with this degree of fire, change the receiver; the under liquor will be found gratefully acid, saline, aqueous, miscible with water, refreshing to the stomach, spirituous and excellently diuretic. It will make an effervescence with chalk, deposite its acidity therein, and afterwards distil from it in form of a pure water: whence the acid salt, and water first come over in this distillation. The other liquor, which floats upon this, is a light, pure, thin, almost spirituous and inflammable oil, thence called the ætherial oil of turpentine, which is so penetrating as to vanish when rubbed upon the body, pass into the blood, and soon communicate a violet smell to the urine; which is an evident sign of the power it has to pass thro' all the pores. (3.) Let a proper receiver be now applied, and an heat equal to that of boiling water, be raised; this is done by pouring water upon the sand, and heating it with the fire underneath to 212 degrees; where it is to be kept by continually adding as much boiling water as exhales away. The matter remaining in the retort, after the first operation, is left so thick as to appear consistent in the cold; but now melts again, crackles between whiles, and again affords an acid water, like the former, that falls to the bottom, and an oil also like the former, floating at the top, but somewhat thicker, and a little yellowish: both of them have nearly the same virtues as mentioned above. (4.) The receiver being again changed, and the fire gradually encreased up to a strong degree of a sand-heat, tho' with caution in the raising it, there will come over an acid, ponderous, red water, that runs separate into the bottom of the receiver, and a thick, red, penetrating, tho' somewhat viscous oil floating on its top; and it is remarkable, that this acid water al-

ways

ways continues to rise along with the oil; and not the water first by itself, and the oil afterwards: what now remains in the bottom after this last distillation, proves, when cold, exceeding red, hard, and brittle. (5.) I have urged this remaining matter with caution, and by slow degrees, up to the strongest heat that sand and a fire of suppression would afford, and have thus obtained red oil, so thick and viscous, as to resemble turpentine itself, but it was of a red colour, and some red, acid, ponderous water still continued to rise with it: leaving scarce any thing behind at the bottom of the retort. (6.) There is the greatest caution required in this distillation, to prevent the glasses bursting or cracking, whereby a dense, oily fume would immediately escape, which readily takes fire, and can scarce be extinguished; whilst the fire is impetuously hurried into the retort with a flame that bursts the vessels to pieces in a dangerous manner. (7.) Turpentine is otherwise commonly distilled into an acid water, an ætherial oil, or spirit of turpentine, after this manner. Fill one third of a bath-alembic (a) with pure rain-water; and add thereto half its weight of good turpentine; then fix on the head, and use the worm and refrigeratory; thus distilling with care, and a fire that makes the matter gently boil, there comes over an acid water, and a pure light oil; if the distillation be continued so long as this oil continues to run, there now remains behind a kind of colophony in the still: and if the flowers of lavender, roses, or other odoriferous plants be here put into the still, the oil will come over fragrant by this operation. Therefore turpentine is resolvable into water, a saline, acid spirit, a volatile oil, and a more fixed colophony. (8.) It is here chiefly remarkable, that the remainder proves so much the thicker, redder, harder, and more brittle, the more water, acid, or volatile oil comes over; and that even this last fixed matter itself at length liquifies, and becomes volatile with the utmost violence of the fire: and this acid water, being well separated and rectified from all its oil, perhaps, affords the best vegetable acid hitherto known.

The use.

1. Hence we learn under what form native oils reside in plants: for first, the nutrimental juice drawn from the earth seems to be a somewhat tart and aqueous liquor, which, when received, gradually deposits its more unctuous matter in certain parts of the plant, and this unctuous matter afterwards uniting more of the same to itself, by heat, maturation, and the assistance of the whole power of the plant, it then appears in the form of a fat oil; which being driven outwards, and undergoing the same changes in a greater degree, at length constitutes a balsam, containing a water, a saline acid, and unctuous spirit, and different kinds of oil, all mixed together, yet separable; and after the separation of any particular part, the balsam constantly changes to a different form. Hence appears the great difference of native balsams in chirurgical and other medicinal uses: whilst they act in

(a) See the chapter of furnaces, furnace the third.

their own substance, and so by means of all their principles together, or only by means of certain, particular, separated parts. When used entire, and mixed with the yolk of an egg, turpentine becomes somewhat more soluble, and an admirable remedy for external chirurgical uses; and internally, it proves excellent in many distempers, where it gives signs of its extraordinary virtue by its penetrating nature, and the violet smell it communicates to the urine. We have many balsams of this kind, not differing so much in virtue, as in price and place of growth, as the *Asiatic, Egyptian, Hiereebuntian, Judaic, Memphitic* balsams, and balm of *Gilead*; for these several names at this day denote the same thing; or a white balsam in the form of a liquid turpentine, and of a citron smell. The *American* balsams are various, and proceed from different trees, as the balsam of *Capivi*, which is of extraordinary virtues; the balsam of *Peru, Tolu*, and liquid amber. The true turpentine proceeds from the turpentine-tree of *Chio*, the fir, the larch, and the pine; but all these kinds generally resolve into the same principles by heat and distillation, change alike with time, and produce the same effects.

2. We know likewise that all the kinds we are hitherto acquainted with, contain an acid water, or spirit, which is volatile, preservative, hungry, or eager and penetrating, of great medicinal virtue and fragrance: this spirit easily exhales, and leaves the balsam deprived thereof, and therefore less excellent; whence these balsams are not the better for keeping.

3. The oils which first come over are light, limpid, totally inflammable, extremely penetrating, bitter, and of great use in chirurgery, as being highly anodyne, resolving, and healing, when applied warm to the membranes, nerves, or tendons, that are lacerated, pricked, or cut; and an immediate, and safe styptic, applied to the wounded veins or arteries in large hæmorrhages; as at once defending the nerves, stopping putrefaction, and incarning. In these cases it should be applied very hot to the part; and kept thereon by a proper pledget and bandage (a). Its balsamic or imbalming virtue is extraordinary; for if the bodies, or parts, of any animals be for some time steeped in this liquor, then taken out, and awhile suspended in the air, and afterwards dipt afresh, they at length acquire a case, under which they may be long preserved from putrefaction: but the bodies plunged into this oil, whilst contained in glasses, are preserved perfectly uncorrupted. It has however this inconvenience, that it gradually grows opaque and thick. The oil being used hot externally, discusses cold, viscid, and mucous tumours, defends the parts against cold, relaxes and softens them. When used internally, it also proves aperitive, heating, sudorific, and diuretic, communicating a quick smell of violets to the urine: whence it proves serviceable in the cold fits of intermitting fevers; and being rubbed along the back bone, before the cold fit is expected, it will even cure quartans. It must however be used with caution, because if taken too largely it affects the head, occasioning heat and pain therein, and also proves violently diuretic, and occasions an effusion of the liquor of the prostrate glands and the *semen*, and, therefore, if used with moderation, it excites venery: hence it came

(a) See Young's *Triumphal Car of Turpentine*, Printed at London 1679. 8vo.

to be recommended in the cure of a venereal running, where it often proves mischievous; as being apt, when freely used, to inflame the parts, and encrease this disorder.

4. The thicker oils that come over in this distillation are more balsamic, incarnative, and anodyne, more penetrating and emollient, and are therefore used as styptics instead of the former thinner balsam, in hotter and more inflammatory constitutions; in other respects they agree with the former: but the last thick, and viscous oil, is an admirable incarnative, that heals almost without suppuration, and a most extraordinary anodyne. This oil also makes such an effervescence with *Glauber's* strong spirit of nitre, as often to take flame.

5. What remains behind upon the distillation of pure turpentine with water, or after the first oil and spirit are drawn over, proves hard, brittle, transparent, and red in the cold. If this be gently melted, and any insect be dipped therein, and carefully taken out again, it will be surrounded with a transparent case like amber, thro' which the subject may be commodiously viewed; and the whole may be thus kept for a long time beautiful and unaltered, provided the polish be not obscured, as it easily is, on account of the great brittleness of this resinous crust. But the colophony remaining after the second distillation is harder and redder, and easily reducible to fine powder which has little smell or taste. This is that extremely useful powder, which is so advantageously applied to the bare bones, *periosteum*, tendons or muscles, in case they are either burnt, corroded, bruised, cut, pricked, or lacerated; and affords an excellent remedy in the serous flux of the joints, and admirably procures a cicatrix: in the same manner it takes down the fungous excrescencies of ulcers; whence it appears, that turpentine serves for many chirurgical purposes. But nothing is here more extraordinary than the successive spontaneous inspissation of the first exceeding thin oil, so as to recover the thickness of turpentine again, and afterwards the consistence of a thicker balsam, and at length of a rosin; tho' there is less acid in these regenerated rosins, than in the native.

6. Possibly, therefore, the native, acid, volatile salt contained in this fat unctuous substance, and in the water, is the same spirit, which, in other essential oils constitutes the aromatic spirit; for it is so lodged in the native fat, as, together with the water, to lye concealed under the form of one mixed body: whence natural balsams are changed into oils upon losing their water, and their rosin. Again, balsams are changed into rosins upon losing their water, acid, and oil; whence this happens spontaneously with time in the open air, whilst the action of the sun, by dissipating the acid, the water, and the thin oil, at length, thro' various degrees, brings it to a rosin. Whence oils in the spring, are rosins in the winter, and in autumn afford a proper covering to trees, so as to defend them from cold, dryness and frost.

7. This experiment clearly shews, (1.) That the utmost heat of the sun, long continued, may gradually inspissate and change liquid oils, thro' various degrees of thickness, up to that of rosin, or colophony. (2.) That the heat of boiling water has this effect sooner; and by discharging the oil, leaves a colophony

colophony behind, in four or five hours time, whilst the exhaling fume proves an acid water, and a spirit mixed among a large quantity of oil; the colophony remaining hard behind. (3.) That this colophony, being urged by an heat of 280 degrees, is again resolved into an acid water, and a red, viscous, ponderous oil, leaving an extremely hard, transparent colophony behind, of a colour compounded of red and black, and capable of enduring unaltered for ages. But when this itself comes again to be urged with the utmost violence of a fire of suppression, so as almost to melt the glass, its whole quantity is, by the sole force of the fire, turned into an oily liquid substance, tho' somewhat viscous, without leaving any hard colophony behind. (4.) Whence we learn both the changeable nature of vegetable oils, and the surprizing variety of the action of the fire upon them; which, with a certain degree of heat, inspissates thin oils, and brings them to an hard consistent mass, that would always remain the same; tho' a greater degree of fire again reduces it to a liquid oil, which likewise would long continue in this state; but by a repeated distillation, with a strong fire, it becomes totally liquid, and considerably thin: whence it is certain that many bodies owe their hardness, and others their fluidity to the fire.

PROCESS XXXVI.

The water, vinegar, fetid spirit, and butter, from wax, distilled by the retort.

CERTAIN balsams appear, in a very small quantity, upon the surface of the leaves of some plants, where they are inspissated by the heat of the sun; as seems manifestly to appear in rosemary. There are also often found in other plants certain very minute globules, rising from the open seminal tufts in the main part of the flower; these can scarce be collected by any human means, but I have sometimes found, upon frequently cohobating spirit of wine upon rosemary leaves, an unexpected and ungrateful taste or smell of wax, fouling the spirit, which before was good; and upon viewing these leaves with a microscope, I thought I discovered little waxy risings of the surface, and upon handling them considerably, I evidently found wax gradually sticking to my fingers. Wax, therefore, appears to be a certain species of turpentine which the fat juices of plants, when heated by the sun, sweat out upon the surface, or produce within the cavities of the flowery tufts. This the bees collect, roll up into little balls, and carry between their hind feet to their hives, where it is wrought into the cells of their combs; and from hence, after the honey is separated from the droffy parts, it is procured for human uses. It is generally yellow, and not ungrateful either in taste or smell; it becomes hard and almost brittle in the cold, but grows soft, and dissolves with heat.

The process.

Half fill a glass retort with fine wax, cut into pieces small enough to enter the wide mouth thereof; then pour clean sand upon it, so as to fill the retort, which is now to be gently warmed till the wax melts, and sufficiently imbibes and mixes among the sand: set the retort in a sand furnace, apply a receiver, and distil with a gradual fire: there usually first comes over a little tartish water, of a disagreeable fetid odour, along with a little spirit; when with the gentle heat of 214 degrees nothing more ascends, change the receiver, and raise the fire; by which means there will gradually arise a thin oil of a whitish colour, and concrete, like butter, in the receiver. When this ceases, apply a violent fire of suppression, upon which the whole body of the wax will soon come over into the receiver, and there appear in a solid form, like butter; having lost the hard brittle nature of wax, and melting oily. So much sand should be here mixed with the wax, as to prevent its explosive swelling, as would otherwise happen in the boiling.

The use.

It is hence manifest that the whole body of wax is volatile, with a certain degree of fire, as we before saw of turpentine; in which respect therefore these substances agree with camphire, tho' camphire be much more volatile than the other two. Hence we see also that wax, which is wholly inflammable, may exist in a hard and almost brittle form; and when dissolved in hot water, then forced thro' a linen strainer, and poured into shallow, metal-line moulds, so as to form little cakes; these being exposed to the open air and sun, and frequently sprinkled with pure water, the wax is thus blanched or whitened; and tho' it now also wholly consumes in flame, yet it is almost as brittle as glass: so as to seem a very different thing from oil. Inflammable vegetable oils, therefore, may exist under the various forms of oil, balsam, rosin, pitch, dry tears, wax and butter. And hence we see, the fire can make true liquid oils from bodies, which appeared not to be oils before; as we evidently see in the distillation of colophony and wax. And this conversion of wax into butter is durable; for it does not return to hard wax again in a very long time, but constantly remains a soft butter, even in the greatest cold. I have kept this butter of wax above twenty years, in a glass cylindrical vessel, whose wide mouth was only loosely covered with paper, yet in all this time it did not return into wax; whereas the most liquid oil of turpentine soon grows thick, like thin turpentine itself; so that the different effects of fire upon the bare oily parts of plants is surprizing: consequently no certain rules can hence be laid down for the action of fire upon oils. Camphire, which is a pure inflammable oil, becomes camphire again, and not a liquid oil, after being raised by the fire. The butter of wax thus prepared affords an extremely soft anodyne unguent, agreeable to the nerves, highly emollient and relaxing, and when rubbed upon the parts
proves

proves serviceable in contractions of the limbs, and successfully preserves the skin from roughness, dryness, and cracking in the cold, or the winter : it also proves excellent in the sharp pains of the hæmorrhoids.

PROCESS XXXVII.

The butter of wax turned into a liquid oil, upon repeated distillation by the retort.

MELT the butter of wax, over a gentle fire, to a liquid oil, then pour it thro' a funnel, first well heated, into a glass retort also well heated before-hand, so as to half fill the retort, with care to prevent any of the butter from sticking to the neck thereof, because in that case the gross matter would fall into the receiver, which should here be avoided. Set the retort in a sand furnace, lute on a clean receiver, and distil cautiously, managing the fire so that one drop may follow another at the distance of six seconds ; when nothing more comes over with this degree of heat, raise the fire, and distil as before, and continue in this manner increasing the fire with the same caution, so long as any butter remains in the retort ; and by this means all the butter will come over, scarce leaving any scæces behind ; and a thickish oil, not much diminished in quantity, be found instead of butter in the receiver. If this oil of wax be again distilled in like manner, it always becomes more liquid, soft, transparent, and thin, so as at length to resemble a subtil, limpid oil : and the oftener the distillation is repeated, the more mild and gentle, yet the more penetrating the oil becomes.

The use.

Hence it appears, that the action of the fire more and more attenuates certain oily bodies of plants, yet without rendring them acrimonious, but on the contrary always milder, tho' at the same time more penetrating ; for this last oil of wax is an incomparable remedy for the diseases of the nervous *papilla* in the external skin, and has scarce its equal in curing chapt lips in the winter, chapt nipples in the women who give suck, and in the cracking of the skin of the hands and fingers, being sometimes gently anointed thereon. It is also serviceable in discussing cold tumours arising on the face or fingers in the winter ; and curing contracted tendons, and the rigidity of the limbs thence arising ; being used along with baths, fomentations, and motion ; for it has a singular virtue in thus restoring flexibility to the parts : being frequently rubbed upon the *abdomen*, it prevents costiveness ; and is therefore excellent in effectually curing the diseases of children.

PROCESS XXXVIII.

Medicated elæosaccharums.

AFTER the chemists had justly shewn physicians, the spirit residing in essential oils, contained, in a small volume, all the particular virtues of the plant; physicians prudently reflected, that they hence had an excellent instrument in their art, but that the unctuous tenacity of the oil still prevented its being used with safety, because these oils being extremely sharp, and by their tenacity remaining fixed to one part, occasioned inflammations. Hence they began to think of a method of rendring these oils miscible with water, and uniformly conveying their entire virtues to the places intended, and this they found might be effected by the means of sugar.

1. Grind therefore an ounce of dry loaf sugar to an impalpable powder, in a glass mortar, with a glass pestle, and by degrees add thereto a drachm of any essential oil, or half a drachm, if the oil be very tenacious, and continue rubbing them together till all the oil be thoroughly mixed, and drank into the sugar; the oil, in this operation, usually diffuses a fragrancy to a great distance; whence the operation should be performed quick, and the mortar be covered with a cloth surrounding the pestle. If a little fresh white of egg be added in the grinding, and mixed in with the sugar and oil, the oil thus becomes more easily miscible, but the mixture will not thus keep so long without turning rancid. And thus sugar, which is a pure soap, or a true essential oily salt, divides the glutinous tenacity of the oil, interposes itself betwixt the principles thereof, unites them closely with itself, and makes an extemporaneous soap; which may thus be commodiously diluted with water for medicinal uses; for tho' this mixture is not so perfect as in an actual soap, or true essential salt, yet it suffices for use: nor is there reason to apprehend any inconvenience from the sugar in this preparation; for sugar is unjustly said to be unwholesom, as there are no proofs extant thereof. On the contrary, it is a wonderful salt that perfectly mixes with water, and ferments therewith into wine; and yet what is again surprizing, it appears oleaginous, and perfectly inflammable in the fire: whence it is known to consist of oil and salt.

2. If these elæosaccharums be well prepared, dried, and put up into clean glasses, exactly closed with glass stoppels, they may long be preserved perfect; and in this manner, very effectual medicines might be commodiously carried from place to place, and upon occasion be directly used upon a journey, by adding a little of the elæosaccharum to a glass of wine. An elæosaccharum might also be made by grinding an essential oil with a fixed alkaline salt, by which means also a kind of soap is obtained; but alcalies thus destroy the grateful properties of the essential oils, and change their natural tastes and odours. Such elæosaccharums also would presently resolve in the air, and thence be easily altered. By the former method,

- method, therefore, physicians may prepare an excellent medicine, rich in
- virtues : for if the elæosaccharum of mint be dissolved in distilled mint
- water, then strengthened with the addition of the spirit of mint, and the
- mixture sweetned with the syrup of the same plant, the whole virtues of
- mint may thus be obtained.

The use.

Hence appears the saponaceous property of sugar, which fits it for breaking and dividing the bodies of oils, as if they were in a manner fermented with sugar ; and at the same time it does not diminish, but rather improves the particular virtues of these oils : whence the ancients, who were unacquainted with sugar, mixed oils with honey for the like purpose. And hence we learn the virtue of sugar in the body, where being diluted with the natural juices, it affords a saponaceous lixivium, which, by the force of circulation, dissolves unctuous and viscous matters : whence it does not generate but dissolve phlegm, nor increase the bile, nor turn into it, but opens, thins, and divides it ; tho' by dissolving the oils too much, it may occasion leanness, as by attenuating too much it produces a weakness and relaxation of the parts, and is therefore often found hurtful in the rickets and the scurvy. In the mean time, this production of nature and art is, as we above observed, very singular and extraordinary ; for it entirely dissolves in water, melts in the fire, shoots like a perfect salt into perfect crystals, is manifestly fixt, and if distilled in close vessels, affords an acid penetrating spirit. In an open fire it becomes wholly inflammable ; it is fermentable, and thus convertible into strong wine, that will afford alcohol ; and lastly, it may be converted into sharp vinegar. If it be called a salt, we may ask how it comes to be inflammable in the fire ; if an oil, how it comes to crystallize ; if an essential salt, how it comes to ferment : so that, perhaps, in all nature there is no other body found in which all these properties conspire ?

P R O C E S S XXXIX.

Medicated liquors, made by means of many of the preceding processes.

THE present and preceding process are principally of use to physicians, who apply the known virtues of plants to the body.

- Take therefore a drachm of any elæosaccharum, and two drachms of
- the medicated salt of *Tachenius*, grind them together strongly, and for a
- considerable time, in a glass mortar, till they become thoroughly mixed ; then
- add six ounces of the cohobated distilled water of the same plant, from
- whence the elæosaccharum was made ; and if a syrup of the same plant be
- kept in the shops, a little thereof may also be added : and thus in a small
- compass the virtue of a plant may be collected together for medicinal use,
- and act according to its own nature in the body. The salt of *Tachenius*
- will not here communicate any virtue foreign to the design, tho' prepared
- from

‘ from a different plant, for as we have shewn from the history of that salt, the particular virtue of plants does not reside in this, but in their essential oil, and the salt itself rather in the common matter of the plant. If a person, therefore, for making this medicated liquor from cinnamon, should add the salt obtained from burnt cinnamon, he would lose more of the spice, or more labour, than the virtue of the liquor would answer.’

By this means the proper virtues of every plant are obtained concentrated, because the elementary water is the same in all plants, and therefore does not alter their effects; the salt also loses its own nature in the burning, scarce retaining more than the common one, and therefore proves of the same virtues, whatever be the plant that afforded it: so that all the peculiar virtue of a plant remains in its presiding spirit, which is here separated and lodged in the oil; whence this preparation is extremely commodious, efficacious and useful, if the medicinal virtue of the plant be previously well known; for thus we obtain a certain, tho’ indeed a less perfect kind of saponaceous, oily essential salt of the plant, than that in which the excellent *Helmont* places nearly all the efficacy of medicines. By intimately mixing these oils with their salts in a compound form, with a secret circulation, we obtain a secret succedaneum for the alcahest; and again a succedaneum even for the alcahest of *Helmont*, is obtained in these mixtures.

The use.

The dose of these medicated liquors is principally determined from the power of the oil employed in them; the time for giving them is chiefly when the stomach is empty, and according to the nature of the distemper. For example, a simple tertian fever, very cold in the beginning, is to be cured after this manner. Two hours before the fit is expected, let the patient use a warm bath to his legs and feet, till he grows moderately hot, and afterwards take every quarter of an hour, half an ounce of the medicated liquor, prepared from the water, oil, and salt of wormwood; then let the feet and legs be well rubbed, and the whole regimen be continued till two hours after the fit was expected. And by this means all these cases are generally cured with ease and safety, even in old age, unless there be any scirrhusity or suppuration attending. So again, in the case of worms, a like preparation from tansey being given for some time upon an empty stomach, proves excellent: but here, instead of the salt of tansey, which is scarce, the salt of wormwood may be employed. Understand the like in other cases.

P R O C E S S X L.

‘Odoriferous balsams artificially prepared from distilled oils, wax and pomatum.

1. TAKE an ounce of perfectly pure pomatum, melt it in a china vessel over a soft gentle fire, then gradually add a drachm of white wax,

wax, fine shaved; and after the two are well mixed, remove the vessel, and when they begin to thicken, drop in a drachm of essential oil, keeping the whole constantly stirring, that it may perfectly mix; after which set the containing vessel in cold water, where growing immediately cold, it may keep in the oil and spirit. When the balsam is thoroughly cold, directly put it up into boxes of lead, or pewter; which being close stopped, it may thus be preserved perfect for years. Instead of pomatum and wax, the express'd oil of nutmeg may be here used, after it has been washed so long in water as to become white, tasteless, inodorous and pure; for this is the common way of preparing these balsams. If they are desired of a grateful colour, this may be easily given them by the addition of a little pigment. Thus, for instance, a scruple of cochineal, reduced to fine powder, will tinge an ounce of the balsam of a pleasing purple; or the same quantity of the inspissated juice of buckthorn of a green; a little native cinnabar ground fine will turn it of a scarlet; fine turmeric of a yellow; or a little smalt of a blue. Any of these pigments therefore may be used at pleasure, provided they have no ungrateful odour, or pernicious property.

The use.

As these balsams are prepared in the way of rich perfumes; and in order to raise the languid spirits, the noblest oils, either separate or artificially mixed, should be used therein: and the principal of this kind are those of baulm, calamus aromaticus, cinnamon, cedar, citron, cloves, jafmin, lavender, white lilies, marjoram, mace, nutmeg, organum, oranges, both those of *China* and *Seville*, roses, rhodium, yellow sanders: to which we add balsam of *Peru*, and balm of *Gilead*; these two being spontaneously fragrant without distillation. The other oils fit for making these balsams are easily prepared extempore.

PROCESS XLI.

All meal and malt afford an unactive liquor, by distillation with water.

MIX any kind of meal into a thin pappy consistence with water, and distil it in a clean glass with a gentle fire, so as to prevent any empyreuma; whereby an indolent water will be obtained, without any inflammable spirit: then take the meal of malt, which we shall soon describe, mix this in the same manner, and distil it with water; whereby again there will be obtained a spiritless liquor, which, as well as the former, contains nothing that is acid, alkaline, oily, or spirituous: or if crude meal and malt be mixed together in water and then distilled, the produce will be the same.

The use.

Hence it appears that no inflammable spirits exist in mealy vegetables before fermentation, not even after the operation of malting, which is a kind of

of dry fermentation. Neither does any nutrimental matter here rise with the water, whose vapour forms drops like dew upon the glass still-head, without running down in veins; the liquor also quenches fire, and when drank proves neither heating, nor inebriating, no more than refreshing, or nourishing. And the process holds of all meal, whether from grain or pulse.

PROCESS XLII.

Honey dissolved in water affords, by distillation, a water impregnated only with the smell of honey.

TAKE one part of pure and perfect native honey, and six parts of pure rain water, mix them well together, and distil them in a glass vessel with a moderate fire; the rising vapour collects in watery drops scattered upon the inside of the alembic-head, without running down in rivulets, tho' two thirds of the water be thus drawn off: nor has this water any vinous odour; but only that of the honey, which often retains the fragrance of the flowers, whence the bees collected it. All the water, which thus comes over, quenches fire, and upon drinking proves very insipid, without heating, or inebriating.

The use.

Hence we learn that even the most elaborated juices of plants produced and perfected in the cells of flowers, and thence collected by the bees, contain nothing at all of that spirit which they afterwards yield by fermentation. Whence we clearly see that the action of the sun upon the juices of plants, so long as they remain therein, can never produce the requisite effect of a true fermentation; and consequently that pure honey has not any heating, drying, or constringing virtue, but only one that is attenuating, detergent, relaxing, stimulating, and saponaceous: whence it has excellent effects both in chirurgical and internal cases. And for this reason, scarce any thing was more celebrated by the ancient physicians than hydromel, or a mixture of honey and water; as being attenuating, aperitive, purgative, and stimulating, yet without heat: our honey-water, however, distilled in a *balneum marie*, receives a certain virtue from the spirits of the flowers lodged in the honey, and thence is accounted extremely useful in the way of *collyrium*, and fomentation, applied in inflammations or obstructions of the eyes; as being in some measure the waters of the flowers that afforded the honey. Our present process likewise holds in certain fresh express'd and inspissated juices of plants, as of manna, the pulp of cassia, sugar and tamarinds, which also, when mixed with water, and treated in the same manner, afford no vinous spirit. And the same holds of other thinner juices, as those of berries, summer-fruits, the birch, the vine, &c. which, also, upon distillation, afford no inflammable spirit; so that the process is universal.

The

The History of Fermentation.

There is scarce any thing more considerable in natural history, more common, or ordinary, in life, or more frequent in chemistry than fermentation; so that we may say, with the excellent *Bellini*, that all things are full of ferments. Especially the chemists may say this; and *Helmont* affirms, that the virtue of ferments is the sole cause of almost every transmutation: but talking too much in the general begets confusion; for if every change proceeded from fermentation, then that word would be no more limited than the word change; whence the true difference of terms would be lost. Hence some men of eminence have justly complained of this confusion, and long wished for a distinct treatise upon the subject, which I shall here endeavour to give.

1. By the word fermentation, I understand an intestine motion excited in vegetables, whereby they are so changed, that the liquor first rising from them, by the force of fire in distillation, is either sharp, miscible with water, of a hot aromatic taste, inflammable in the fire like oil, thin and volatile; or else sharp, acid, capable of extinguishing fire and flame, less volatile and thin. This definition limits the term for fermentation; so as to comprehend whatever occurs in a real fermentation, without suffering the word to be applied to any thing else, which it less justly suits. There is at once an intestine motion in the whole mass and all its parts, in every fermentation, so long as it continues: I call it intestine, because it is chiefly excited by the internal principles contained in the vegetable. I allow there is somewhat here required, but this would not excite a true fermentation in the body, unless there was a disposition thereto in the subject. For pure water, spirits, oils, or salts, being kept in the same heat, would never run into fermentation. I say this intestine motion can be excited in vegetables only, because there has hitherto appeared no instance of fermentation in animals; unless where the animal had taken in vegetables, and not wholly converted them into its own nature; and for minerals I do not remember that any fermentative motion has been observed therein, tho' I know that some very eminent authors write as if there had. It is the office of reason to distinguish justly, and therefore I ought to define this operation from its effect; because a true and perfect fermentation always terminates in the production of a spirit, or an acid, as we have described them. That there may be some issue out of this confusion, I would ask all the more prudent chemists, whether that action of vegetables, here described, is not termed fermentation? They seem all to allow it. I would again ask, whether therefore the law of distinctness and order does not direct all those actions, which produce not these effects, to be called by some other name? I think reason declares for it; and therefore tho' putrefaction be an intestine motion in vegetables, yet, as it affords putrid oils, and fetid volatile, alkaline salts for its last effect, I will thoroughly distinguish this operation from fermentation. So the putrefaction of the animal juices is also a true intestine motion, yet never produces acids, or inflammable spirits, but the matter of phosphorus, and therefore differs

entirely from fermentation; for if it does not produce an inflammable or acid spirit, I shall avoid calling it fermentation for fear of confusion. No more can the various effervescences, which we shall hereafter explain, be justly esteemed as fermentation; tho' these also are intestine motions, and often happen in pure vegetable subjects, as in strong vinegar, and fixed alkaline salt.

2. Any fermented vegetable liquor, that by distillation first affords an inflammable spirit, capable of mixing with water, I call wine, from whatever vegetable subject it is procured. And again, every vegetable liquor so fermented, as, in its first distillation, to afford an acid liquor, capable of extinguishing fire, I call vinegar, from whatever subject it was produced: so that the effect of a perfect fermentation will be either wine, or vinegar (a).

* See §. 1.

† See §. 2.

3. I call that a fermentable body, which may be so changed by the action above described *, as thence to produce either wine, or vinegar †. And as this was never found to happen in other than the vegetable kingdom, hence I am obliged to acknowledge, that vegetables alone are fermentable; and yet it will appear that all vegetables are not fermentable.

‡ See §. 3.

|| See §. 1.

4. I call that body a ferment, which, when intimately mixed with a fermenting vegetable ‡, excites, encreases, and promotes the fermentation above described ||: whence it appears that all ferments are of the vegetable kind.

5. The fermenting vegetables are extremely various; and are therefore to be distributed into so many classes, as they require different methods of fermenting; for we should neither use more nor less of such: thus as rye requires one treatment for the making of wine, and a fresh express'd juice of grapes another; these two fermentable bodies must be distinguished into two classes. On the other hand, as wheat, oats, and barley, require the same treatment as rye, these are not to be distinguished between, but all reduced to one and the same class. In the mean while we must observe, that not all vegetables, but only certain kinds, are fit for fermentation; for those above set down, under our thirty-third process, abound with a copious, native, alkaline salt, or else are easily changed into it, and are therefore indisposed to ferment, and apt to putrify. This I found by experience in onions and rape, from whence, when I first applied to chemistry, I hoped to have obtained by fermentation a spirit serviceable for the stone, but was frustrated in my expectation; for an alkaline, fetid, volatile salt, and a similar spirit are afforded by these subjects, rather than one of the inflammable kind. Hence all fermentable bodies may undergo putrefaction, but not all putrefiable bodies undergo fer-

(a) The difference here laid down is arbitrary; and, perhaps, the author by admitting vinegar, as well as wine, for the criterion of fermentation, has in some measure defeated his own intention of limiting this operation: might not any one with as much reason add, that the affording of a volatile salt for the first thing in distillation, is the effect of

another species of fermentation, called putrefactive, as that which produces vinegar is called acetous, or that which produces inflammable spirit is called vinous? Certainly this subject requires accuracy, and an extensive knowledge of physical effects, before it can be justly settled.

mentation:

mentation: so that in this respect there is a great difference between vegetables, as may be seen above in our thirty second, and thirty third processes.

6. These things being carefully observed, we may range under the first class of fermentable bodies all those seeds, which, when ripe and dry, may be ground into a fine meal, not an unctuous paste; and to these we may add the seeds, which, tho' they abound with oil, yet may be so changed by art, as to be afterwards reducible to a less unctuous meal. We must therefore subdivide these mealy vegetables into three sorts, viz. (1.) The ripe seeds, culmiferous, growing in ears, and having a grassy leaf, usually called grain, such as barley, buck-wheat, millet, oats, rice, rye, wheat, &c. and other seeds, on account of their affinity, as flax-seed, canary-seed, the seeds of cucumbers, melons, pumpions, lettuce, &c. (2.) The several seeds of pulse, as beans, cammoc-seed, *French* beans, heath-beans, lentils, lupines, pease, cicers, tares; with the mealy seeds of all other podded vegetables, which bear a papillaceous flower. (3.) All the nuts, not over oily; as the almond, chesnut, cocoa-nut, hazel-nut, horse-chesnut, pistacho, walnut, &c. which if too rich in oil are first in some measure to be deprived thereof, as they may be by sprouting and torrifaction.

7. The second class of fermentable bodies contains all the pulpy summer's fruits, abounding with ripe, tartish, and sweet juice; such as apples, apricocks, barberries, citrons, cherries, currants, elder-berries, gooseberries, grapes, lemons, medlers, mulberries, oranges, pears, peaches, plums, raspberries, services, &c. provided they tend not to a ferid alkaline putrefaction.

8. The third class contains the succulent herbs, and all their parts, as flowers, leaves, roots, and stalks, provided they rather incline to acidity, than putrefaction: whence those exhibited under the thirty third process are here to be excepted.

9. The fourth class contains the fresh express'd, and native juices of plants, especially of their fruits above set down*: to which may be added all the juices which distil from certain trees, when wounded, especially in the spring, as the birch, the walnut, and the vine: for all these juices generally run into spontaneous fermentation, and then almost change their nature; and thus alter from cooling, acid, and stimulating, to heating, inebriating, and vinous. The elder *Helmont* recommends the water flowing by incision from the birch tree, as a secret against the stone, if used fresh, or after being kept perfect: Mr. *Boyle* confirms the observation by the experience of himself, and others; but found it had this virtue whilst it remained recent, because its nature was quite changed after fermentation.

* See §. 7.

10. The fifth class again contains those vegetable juices, which are formed and inspissated by nature, into a certain saponaceous substance, consisting of saline and oily parts; as honey, the pulp of cassia, manna, sugar, and all the other species of these juices, which are not balsamic, gummy, resinous, or unctuous.

11. I have some doubt about making a sixth class of river waters; these indeed seem to be common lixiviums, impregnated with all kinds of vegetables that fall into, and resolve therein, and thus at length become inti-

mately

The Practice of CHEMISTRY.

mately mixed. So likewise fresh fermenting vegetable liquors are discharged into the drains and sluices of populous cities. If such waters, therefore, be put into casks, which before contained beer, wine, or vinegar, they may here for a long while conceal much spirit, and afterwards coming under the equator, or into the torrid zones, and feeling a great heat, they may be thus raised into a kind of fermentation (*a*). And under these six classes, I judge, that all the bodies capable of fermentation may be ranged, provided each be treated in the method it requires.

12. There are certain physical conditions requisite, to render the subjects of the five former classes the fitter for fermentation, *viz.* (1.) A perfect degree of maturity, suitable to each kind; for all seeds and fruits which are so perfect, as when sown in fertile ground at a proper season, and in a proper climate, to produce a plant of their own species, are fit for this operation; but when they are crude, austere and watery, they are less disposed thereto. Thus the immature and austere juice of grapes does not readily ferment, but the juice of ripe grapes presently runs into fermentation; and the same generally happens in other subjects. (2.) Another requisite to fermentation is a moderate proportion of oil; for fat subjects rather grow rancid than ferment, yet if entirely deprived of oil, they are thus also unfitted for fermentation. Thus bruised almonds, which are rich in oil, will scarce ferment; but may be made fermentable by grinding them well into an emulsion, with a large proportion of water: so again, when they are steeped with water, then made to sprout, their oily part is thus much lessened, and they made fitter for this operation. (3.) The subject must not be too austere or astringent, for then it would ferment with difficulty. Thus the juices of bistort, tormentil, &c. will scarce undergo this operation. (4.) Solubility in water is a principal requisite in a fermentable subject. Thus barks, roots, and woods, so long as they retain this form, do not ferment; but their expressed juices, now made capable of mixing with water, readily enter into fermentation.

13. The principal ferments are these, (1.) All those things which of their own nature are greatly disposed to ferment, so as immediately to begin this operation without any other ferment; such as particularly the juices of ripe summer fruits, which are so strongly disposed to ferment, as scarce to be kept quiet without the help of things that prevent fermentation. So likewise a paste made of flower and water, and laid in a warm place, cannot then be hindered from fermenting. Hence we need not be solicitous about a first ferment, because nature spontaneously affords it every where. (2.) The recent flowers, thrown to the top of beer, in the act of fermentation; for if this rarified frothy matter be mixed with other fermentable liquors, it greatly promotes their fermentation, provided the flowers be fresh, and not shrunk, or fallen. (3.) The same matter now become heavier, and sunk to the bottom, provided it be not too stale, still retains the same virtue, tho' in a less degree than the former. In this state it is called lees; and being by motion mixed with its own wine, it often occasions a new fermentation,

(*a*) See theory, chap. of water.

and will excite it in other subjects. (4.) Cassia, honey, manna, sugar, and the like inspissated juices. (5.) Acid paste of flower fermented, or bakers leaven: for tho' meal may be preserved, for years, fresh and sweet in a dry place, and kept from insects; yet if wrought with water into a soft sweet and close paste, and lightly covered in a warm place, it will in an hour's time begin to heave, swell, rarify, become all over full of cavities, change its smell, taste, and tenacity, prove acid both to the taste and smell, and thus become that proper ferment, which gave the original name of this whole operation: because, when thus prepared, if a part of it be mixed with other fresh paste, not yet fermented, it now causes it to ferment much sooner and stronger. Whence we have a quick way of preparing a ferment without the assistance of a formal ferment. (6.) The remains of former fermenting matters sticking to the sides of the casks; for casks, every way penetrated by the subtilty of the wines they before contained, become extremely apt for raising a quick and violent fermentation in fresh liquors put into them. (7.) There might here be added, tho' somewhat improperly, the white of eggs beat up to a froth, but in some cases this is requisite: for when the fermentable liquor is so dilute and thin, as too easily to let go and discharge the air and spirits which cause and support the fermentation; or not to retain these a sufficient time for changing the nature of the liquor; the tenacity of the white of eggs here makes the liquor sufficiently thick to entangle the moving spirits the due time. This therefore does not properly act as a ferment, for it would soon putrefy, but assists the causes of fermentation, by keeping them from exhaling too quick: and the same end may be answered by other viscous substances. (8.) Hence, also, both acid, austere, and alkaline salts have been esteemed ferments, as being useful in certain cases; as where the fermentable matter was too acid to ferment kindly; for in this case, by a prudent addition of a little alkali, the operation may easily be promoted. Again, if any thing putrefiable should arise in the fermentable subject, the sparing and careful addition of an acid may restore the lost power of fermenting: whence it appears that these things are not ferments in themselves, nor indeed fermentable, but become assistant by a particular quality only, or by removing the obstacle of the operation. Tartar, however, if it be good, may in some respect be called a ferment. (9.) Lastly, it is observed, that very austere bodies being added to those which are less fermentable, sometimes procure, and in other cases hinder fermentation. Hence, quinces, austere cherries, unripe medlers, and the like are referred to the class of ferments; but this is properly done only when the fermentable liquor is of itself too dilute, thin, and broken, so as to require some austerity to fit it the better for retaining the volatile spirits.

14. We now proceed to consider those preparations which the better fit fermentable bodies for fermentation. The subjects, therefore, enumerated under the first class, require a particular previous preparation. (1.) Thus the ripe, dry, and perfect mealy seeds are first steeped in rain-water, especially in the spring season, in large vessels, and warm weather, and here left so long till they have imbibed as much as they can of the water, and are grown plump and swelled therewith. (2.) Being now taken from the water, the

the grain is thrown into a large heap, in an open place, a little exposed to the wind, where an impregnating heat soon rises, and by means hereof the vital parts of the seeds are excited, rendered active, and begin to sprout, shooting forth their little seminal leaves, and first rudiments of roots; at which time caution must be used to prevent the heating mass from beginning to putrefy, and again, from sprouting too long, and shooting into leaves and roots, which would consume the mealy substance: for the fermentation always proceeds the better, the more exactly this sprouting is performed, which ought to be neither too much nor too little. (3.) As soon therefore as the sprouting is sufficiently come forwards throughout the whole heap, the grain must immediately be spread abroad somewhat thin, to prevent its continuing hot, as it would do in a large heap; and that it may be thus exposed to the air, and be dried and cooled by admitting the wind in at the open windows, especially the north wind. By this means the farther sprouting is presently stopped, whilst the mealy part remains attenuated, but not consumed by this action; and being now suffered to run slowly thro' a metalline trunk, considerably heated, it is thus suddenly dried, or very moderately scorched, or roasted, and is now called malt; or in the language of *Tacitus*, *frumentum corruptum*. The change, which here happens to the grain, is principally this, that its viscidty is so far attenuated, that whereas wheat will not dissolve in hot water, malt will give out a large part thereto, or suffer its meal to dissolve therein: and thus crude wheat being chewed in the mouth becomes a glue, that can scarce be attenuated by the continued action of mastication; but when the wheat is malted and chewed in the same manner, it readily dissolves in the mouth. Malting also procures an agreeable and very sweet taste, which the wheat had not before. A little before this malt is used, it is ground into a coarse meal, called by the name of ground malt; and what we at first said of wheat holds of all the seeds abovementioned, in our first class of fermentable bodies; for if beans be made turgid with steeping, then suffered to sprout in a large heap, and afterwards immediately dried with a great heat, and then ground, the phenomena, and effects will be the same (a).

15. The subjects of the second class are prepared by pressing, squeezing, or bruising the soft or pulpy substances, so that their fermentable juice may come out; but if they are more fleshy and hard, they may then be boiled in water, and so become a soft pulp, as is often done in pears and apples: but if the subject be dry, strong and tough, let it be rasped, bruised with water, and so brought to a pulp, as in tuberoses, and other bulbous roots, not apt to putrefy.

16. The subjects of the third class are to be bruised, whilst fresh and juicy, to a pulp along with so much water, as may make the pulp thin, and sufficiently dilute; and this is all the preparation they require.

17. If the subjects of the fourth and fifth classes are too thick of themselves, they require to be diluted with such a quantity of water that the liquor may support a fresh egg; but if these subjects are too thin or weak, and a well fermented liquor be required from them, the juices,

(a) See Philosoph. Transact. N^o 142. p. 1096. and *le Fevre, de la fermentation*.

while they are fresh, and before they have suffered fermentation, must be boiled over a gentle fire, in a wide and shallow vessel, till they acquire the requisite thickness, otherwise they would scarce ferment, or afford much spirit. But when they are too thick, they are to be let down with water, to the standard above-mentioned, otherwise they scarce afford any spirit. Dry sugar remains unchanged in the hottest air; but if brought to the thinness of fresh cream, it ferments violently, and becomes a liquor exceeding full of spirit (a): and the same holds of honey, &c.

18. We are next to consider what quantity of ferment is requisite to be added to the fermentable bodies abovementioned, when prepared for fermentation, that the operation may succeed the better. And here we are first to observe, that the preparations of the first class, when reduced to malt, scarce require any ferment in the summer, but then spontaneously, and sometimes too strongly fall into fermentation; but in the winter they require the addition of some ferment, and the assistance of heat to make them ferment quick. If therefore they are kept in a warm place in the winter, they require less ferment, and for this purpose a small addition of yeast is sufficient; viz. an ounce to twenty pints, or the same proportion of honey or sugar, or twice the quantity of baker's leaven. The subjects of the second class scarce ever require any ferment, unless the weather be too cold; and if the fermentation proceeds slow on this account, let a little yeast be added. The subjects of the third class also readily ferment in the summer, if the weather prove hot; and in the winter, if the fermentation languishes, it may be quickened by the addition of honey or sugar, as was sufficiently shewed under the seventeenth process. The subjects of the fourth class very seldom require any ferment, and in hot weather can seldom be kept from fermenting, or moderated therein, especially when the heat is great, and the fruit well ripened. The subjects of the fifth class also require no ferment, as being rather ferments themselves: they only require an artificial heat to be raised, and kept always equally to the same height; whence we learn, that ferments are seldom required than is commonly imagined.

19. After any of these fermentable bodies, therefore, have been so prepared, and properly diluted with water, in the manner above-mentioned, let them be put into a cask of oak, where the like liquor before had first finished its fermentation; so that the cask may remain well impregnated therewith. Set it in a place where the heat is raised between sixty and seventy degrees, and leave the bung-hole open, that the air may freely enter and come out again; or only cover it with a linen cloth, to keep insects from falling in.

20. If we take very large glass bodies, and place them upright in a wooden chest, so that they may be kept in an equal heat, by means of a little fire placed below, and then three fourths of them be filled with a crude fermentable matter, well prepared for the operation, the orifice being slightly

(a) I suppose the author has his eye upon the syrups: which will sometimes ferment violently in hot weather; but to make a solution of sugar or honey, so strong as is here

mentioned, is not the way to obtain a wine or a spirit to advantage in any moderate time, unless a great degree of heat be used.

covered

covered with a cloth, and a heat between sixty and seventy degrees, kept up even in the winter season; it will be pleasant to observe the several appearances of fermentation, and which always obtain, and may be observed in the following manner. (1.) The whole mass at first resting, and possessing a certain space in the vessel, gradually begins to swell, rise, rarify, and conceive an intestine motion thro' its whole body, acting upwards, downwards, and sideways, in strange circumvolutions, without ceasing, tho' with a different force: in the mean time, bubbles being every moment formed in every part of the mass, and constantly endeavouring to rise up, where they burst with an hissing noise, and often break in the mid-way. Hence the whole mass froths, especially on the surface, whilst at the same time there is discharged, with an audible ebullition thro' the whole body, a certain sharp and tartish spirit, that proves acrimonious to the nose, surprisingly elastic, incapable of being confined, and capable of bursting almost any vessel by its great explosive force; in which respects, no other liquor, so far as I know, can be compared therewith. And hence the great *Helmont* thought proper to give it the name of wild gas. (2.) In the progress of this action, all the fermentable grosser matter of the mass begins to rise at the top, and separate from the other liquor below, so as to collect into one thick spongy crust, exactly covering the liquor underneath, keeping in the more active parts thereof, and returning them downwards so as to prevent their exhaling, and being dissipated before they have performed their effect. And now it is pleasant to see how great an agitation there every where constantly is, even in the least parts of the whole fluid matter, below the tenacious crust already described; certainly, a greater attrition can scarce be conceived, than that here made with the utmost rapidity among all the corpuscles; and hence the crust being successively broke, and raised upwards, with a considerable noise upon the returns of the explosions, the exhalations escape, whilst the crust, presently falling together, closes again, and prevents the active principles from otherwise exhaling: and thus the formation and continuance of this crust is highly assisting to the due performance of fermentation. (3.) In the mean time, as soon as all the gross fermentable parts of the mixture are thus collected at the top, some less rarified parts of the lower part of this crust, being no longer sustained by the light bubbles, which occasion them to ascend, they begin again to sink thro' the fluid, and are agitated upwards and downwards, form bubbles in and about themselves, and, by means thereof, are again raised to the top, where the bubbles breaking, they again fall downwards; and when they have done thus for several times reciprocally, these parts at length remain quiet at the bottom; and after this, new little masses do the same; so that after some continuance hereof, it frequently happens that the whole upper crust, now growing heavier, or less rarified, on account of the spirits discharged, sinks of a sudden downwards, but soon after rolls upward almost entire, with a surprizing and scarce credible force, unless it were seen. And now after the whole upper crust is entirely consumed, and fallen to the bottom, the fermentation ceases, tho' the same degree of heat be continued; at which time the liquor become transparent, thin and light, floating over the faeces remaining

ing at the bottom. (4.) Hence in every true fermentation, the fermentable matter is first always uniformly mixed, then separated into two parts, or a thinner fluid below, and a thicker crust at top. This crust at top, so long as it remains there, is called the flowers of the fermentable matter, and is one of the most proper and immediate ferments. Next, in the second stage of fermentation, the liquor is separated into three parts, viz. the flowers, a middle fluid, and a matter beginning to fall, and collect at the bottom, called *feces*, or *lees*; being the more gross and ponderous part, exhausted of all the principles that occasion fermentation. Thirdly, In the last stage of fermentation, the matter is again separated into two parts; the upper, a clear, thin, pure liquor, called wine; the other a gross matter, lying at the bottom, called *lees*, or the mother of wine. (5.) There is nothing more extraordinary in this fermentation, or that deserves more carefully to be observed, than the surprizing wild spirit, which violently breaks out in the strength of the operation; as I do not remember that so immediate, mortal, and subtile a poison has been hitherto discovered; for if a large vessel, full of the best fermenting must, now in the height of its action, should discharge its condensed spirit thro' a small orifice made in the upper part of the cask, and a strong healthy man should draw in at his nostrils the vapour collectedly issuing out thereof, he would instantly fall down dead, without any distemper; or if he received but little thereof, become apoplectic; or if still less, he would remain an idiot his whole life, without common sense, or become paralytic. And the same accidents befall those, who imprudently remain long in such wine-vaults, where wines are fermenting in the vintage season, if the vaults remain shut up. For which reason they are obliged to air these places, by setting open the windows, lighting a fire, and admitting the wind, as is every where well known. It is also related, that a spirit has been drawn from sugar, and the scummings thereof, first dissolved in water, and then fermented; which spirit being received in a very small quantity into the lungs, instantly stopped all respiration, and gave an intolerable asthma (a). Hence physicians should consider what effect such liquors may have in the body, as are drank in a state of fermentation, or that spirit which in the summer season is generated in a hot body, by too free an use of ripe summer fruits, if prevented to escape by any convulsion, or constriction of the stomach: whence these fruits would acquire and exercise a violent elasticity and acrimony in so warm a place. And hence a considerable quantity of this poison still remains in spirit of wine, the vapour whereof, when long and largely received at the nose, produces a high degree of inebriation, which is but a lighter apoplexy; and if drank too freely, it principally hurts the brain, the nerves, and their functions. In the mean time, it is uncertain whence this spirit proceeds: it is doubtless the creature of an active and immediate fermentation, nor do we know that the same thing is produced by any other cause. We cannot understand how it should occasion death, without causing any disease, or producing any apparent alteration in

(a) See *Philos. Trans. abridg. Lowth.* vol. II. p. 635.

the brain, *cerebellum*, nerves, juices, or solids. As soon as the fermentation is finished, it is proper to close the vessel, and let the fermented liquor stand for some time upon its lee; a great part thereof will thus be consumed, and assimilated by the liquor, which will now become stronger, and richer in spirit, than before, especially for the use of distillation.

21. The time required for the perfect finishing of fermentation can scarce be exactly determined, as being different in different places, and according to the seasons of the year, the difference of heat, winds, and the subject itself. The juice of the palm-tree in *Africa* finishes its fermentation in a few hours time. In *Asia* likewise this operation is presently over; but in the northern countries it proceeds slower. In the heat of summer it proceeds quick, but in winter more languidly. It is promoted by the south wind, and retarded by the north. The juice of grapes and sugar ferment with a sudden violence, but other things more slowly. It is however easy to know when the fermentation is finished, *viz.* when the whole series of the phenomena above described, has successively appeared, and is at length spontaneously gone off; at which time the vessel is immediately to be stopped down, and the fermented liquor kept upon its lee; otherwise the spirit produced in the fermented liquor, would soon exhale, and leave a vapid useless fluid behind: but if the liquor be kept quiet, in a well closed vessel, it gradually becomes more subtile, pure, and spirituous. Thus the fresh express'd juice of grapes may be inspissated by boiling without diminution to its virtue; but when fermented and exposed, even to a cold air, it presently loses all its spirit.

22. The liquor thus obtained, by a perfect fermentation, has, in all ages, amongst all nations, and in every language, been called by the name of wine, from whatever subject it was made: but the common nature of all wines is known by the following signs. (1.) It has the faculty of inebriating, or altering the actions of the spirits, and animal functions, by exciting, refreshing, animating, and exhilarating the person, disposing to mirth, eloquence, poetry, and dancing; at length it raises the latent passions, discloses secrets, afterwards disturbs, weakens, and destroys the external and internal senses, and voluntary motions; so that neither the hands, the feet, the tongue, or the mind, can now perform their office; and thus it brings on sleep, the palsy, the apoplexy, and at last death itself. And this is esteemed the peculiar virtue of wine; nor am I hitherto acquainted with the like property in any other subject. For the case of henbane, tobacco, opium, and thorn-apple is very different, when they affect the brain. And this virtue is nearly the same in all wine; for malt-liquor, mead, cyder, perry, the wine of goose-berries, grapes, and other berries, have always the same effects, when properly made; so that this surprizing power is peculiarly owing to the efficacy of fermentation alone. (2.) This operation also changes the relaxing, resolving, saponaceous, cooling, and generally purging virtues of vegetable juices, into such as are strengthening, coagulating, drying, and heating. Thus all farinaceous subjects mixed with water, into a thin pappy mass, the fresh infusion of malt before fermentation, hydromel, syrups made with sugar, a solution of manna, or the pulp of cassia in water,

water, the recent express'd juices of ripe summer fruits, and the ripe summer juices of fermentable plants; all of them, when plentifully drank, prove flatulent, cold, purgative, and weakening; but when properly fermented into beer, mead, and wine, they have quite contrary virtues, or an entire new set which they had not before. Thus the rich juice of perfectly ripe grapes is a violent dissolver of the animal juices, and, when drank immoderately, often occasions a mortal bloody-flux. The inspissated decoction of malt, when plentifully drank, has the same effect; but make the former into a strong old wine, and the latter into a strong old beer, or distil a brandy, or spirit of wine from them both, and thus remedies are obtained for the preceding disorders. (3.) It is a very peculiar property of this fermentation, that it produces, from the fermented liquor, a certain spirit which is convertible into lucid flame, and yet may be perfectly mixed with water. This spirit is of a very different nature from that wild one above described, which seems to be generated in the act of fermentation, but afterwards lost. The spirit, we here speak of, has scarce any where its equal; for the volatile inflammable one, which I formerly saw, with no small danger, burst from the retort, in the distillation of phosphorus, could not be diluted, and extinguished with water; and that which flies off from human excrement, long kept in a large quantity, and in a close place, where the matter is highly putrefied, and which upon the approach of a candle turns into a violent and dangerous flame, seems indeed of the same nature, but is intolerably fetid. So again, when oily matters, distilled with the utmost violence of fire, afford white bluish fumes, these also catch flame upon the approach of a candle, but return to oil or phosphorus, that will not mix with water: so that, when all things are well considered, I do not hitherto know a liquor that will absolutely, and, as it were spontaneously, mix with water, and at the same time remain convertible into pure flame, except this one produced by fermentation. (4.) We have already explained in our eighth process, the manner of procuring tartar, tho' this is not afforded by all sorts of wine, nor even the best malt liquors, nor mead, and many other sorts of wine; but from whatever vegetables it is obtained good and pure, it is only thus produced after the wine has perfectly finished its fermentation, and is become thoroughly fine and bright. And hence I always esteemed tartar as the production of fermentation, and think proper to call it the essential oily salt of wine; with care to distinguish it well from the lees of wine. (5.) There is here a surprizing change of the smell, taste, native and medicinal virtues of the subject, as appears by comparing our sixteenth and seventeenth process together; for the cohobated water of rosemary differs extremely, and in every respect, from that prepared by fermentation with honey. The fresh express'd juice of ripe *Rhenish* grapes has a very sweet taste; but when perfectly fermented, and suffered to rest in the cask, it tastes gratefully tart and pungent. Other wines, not perfectly fermented, but stopped before the operation is fully ended, remain sweet; but then easily fall back into a new fermentation, and, when that is finished, turn sour. *Aloes* and *Coloquintida* are observed by *Wedelius*, to lose their bitterness upon fermentation.

fermentation (2) and I myself have produced very pure spirits from malt-liquors, mead, cyder, wheat, and grapes; and conceive no difference could be found between them. (6.) This new odour, taste, and virtue may be properly called vinous, and is generally attended with a tartish, heating, unctuous property, along with something of the malt, honey, or sugar. (7.) These spirits are produced, either from a matter before of a very different nature, or else from the oil of the subject: the latter seems very probable; but then it may be asked, what oil it is? Chemists generally say from the essential oil; but I do not perceive by what experiment they prove it: for the presiding spirit, which constitutes the essential oil, is lost in the fermentation; besides much oil remains in the matter after it is fermented, and even after it is distilled for its spirit; but I could never bring the remainder to ferment afresh, nor by any art produce any more spirit from it. So that in every fermentable subject there is only one determined part fit for producing spirit, and that only in a certain quantity, by fermentation and distillation; and it is impossible to procure more. But this also must be considered, that pure white-wine, when the fermentation is perfectly finished, produces a white tartar, which is full of a perfectly inflammable and penetrating oil, tho' no inflammable spirit, such as wine plentifully affords, can by any chemical experiment be drawn from it; whence it appears, that the matter convertible into this spirit by fermentation, is perfectly peculiar, whilst yet an immense quantity thereof is continually generated, consumed by animals, or exhaled into the air by the fermentation which produces these spirits, and which is now every where practised. But the *saliva*, blood, and urine of the animals, that daily take in these spirits, scarce afford any by distillation; and yet there is no where any want of fresh matter to produce them, by the help of fermentation: this deserves to be well considered. Fermentation also produces something saline, as appears by the acid, which is considerably volatile, tho' less so than the spirit; for a volatile, acid, and unctuous salt, is produced in vinegar, which did not appear in the matter before it was fermented. The spirit also acquires somewhat of this volatile acidity in the fermentation; hence the oils and salts of fermentable subjects seem to be subtilized, volatilized, united and consumed in a certain proportion in fermentation. For if rosemary, without being fermented, is distilled with water, it affords an oil, having the true smell and taste of the plant, and a white water impregnated with the same virtues; but if fermented with honey, and distilled before the fermentation is finished, it affords a white water, thick, opaque, and unctuous, rich in the virtues of the rosemary, with some oil, tho' less than before, swimming on the water. Lastly, if the fermentation be perfectly ended before the matter is distilled, it affords a pellucid spirit, that mixes with water, and abounds in the medicinal virtues of the plant, whilst no oil of the essential kind any longer appears. (8.) The spirit produced by fermentation, participating of an oily nature, becomes more volatile than water; whereas the essential oil, before the fermentation, was not so volatile.

(a) See *Ann. Lippens*, 1686, p. 366.

as water; but the vegetable, by means of a gentle heat, might be deprived of all its water, without suffering any oil to rise at the same time.

23. The things that promote fermentation, or tend to the better performance thereof, are these: (1.) Rest in the fermenting mass, that the skin, formed on the top, may remain unbroken; for if this were to be continually stirred in, and mixed among the other matter, the effect of fermentation would not be produced. (2.) A free admission and emission of the common air, which also requires to be intimately mixed in the subject, either by treading, kneading, or pressing; and without this admission the fermentation will cease. (3.) The warmth before directed, *viz.* that between sixty and eighty degrees at the most. (4.) It is said also, that the spring and autumn favour the operation, whilst the plants flourish, which afforded the wine; and hence wines are said to grow easily rosy, and ferment afresh in these seasons.

24. The things which check or hinder fermentation are chiefly these, (1.) The acid fume of burning sulphur, received in a large quantity at several times, and shut up along with the air, remaining on the top of the fermenting liquor. For if the whole cask be first penetrated, and filled with the fumes of burning brimstone before the fermenting liquor is put in, and then the empty part on the top be well filled with the same, and the vessel now cautiously bunged down, the fermentation will be stopped; and if after some time it should begin again from the prevalency of its own causes, it may again be suppress'd by the same fumes. And the same end is obtained by mixing a large quantity of any powerful acid with the fermenting matter, as the acid spirits of alum, nitre, salt, sulphur, or vitriol; tho' these at the same time spoil the fermenting liquor. (2.) Alkaline salts, also, if added in a large quantity to fermenting liquors, immediately excite a greater effervescence, which presently ceasing, all farther fermentation is stopped. But here also the fermenting liquor is spoiled, so that it can scarce again be brought to ferment, tho' it may to putrefy; and hence it appears that alkalies resist fermentation, more than acids, by suffocating, or changing the nature of the whole acid part. (3.) And hence all those things which destroy acidity by drinking it up, hinder fermentation, after a short effervescence, if mixed therewith in a proper quantity: thus chalk, coral, crabs-eyes, pearl, testaceous substances, iron, lead, and tin have this effect. (4.) The stopping up of the containing vessel so close, that nothing may escape or enter, provided the vessel be so strong as not to burst by the force of the confined liquor. This is manifest in new malt-liquors, which when included in strong bottles, well stopped down, and afterwards receiving the air, for some time excluded, it turns the fermentation into a violent effervescence, which exerts a very great force: and the same is every where found in casks; for the fermenting liquors, and the sides of the containing vessel, mutually act upon, and press each other. (5.) Too great a degree of cold likewise stops all fermentation, which can scarce go forward with less than thirty six degrees of heat. (6.) Too great heat, which if it exceeds ninety degrees, rather dissipates and throws off the active principles of fermentation, than excites and promotes them; whence a strong exhalation, performed with a greater heat, renders the fluid so thick, as perfectly
unfits.

unfits it for fermentation. But boiling has this effect much sooner, so that the most perfect juice of grapes, that could not be kept from fermenting, loses by quick boiling all its disposition to fermentation, and afterwards remains a quiet mass, unchanged for years. (7.) The extraction of the elastic air, by means of the air-pump, in which state none of this motion is exerted. (8.) And lastly, a violent compression of the same air, with the fermentable matter, entirely prevents the origin, and stops the progress of fermentation.

25. When the liquor is perfectly fermented, it should be put up along with its flowers and lees into very close and well filled vessels, and suffered to stand for some time in a cold quiet place, where having thus produced more spirit, the whole becomes fit for distillation; in order to which, the liquor is by motion to be mixed along with its lees, because it thus affords much more spirit; but then care must be taken in the distillation, that the lee does not fasten to the bottom of the still, and there scorch and burn, so as to make the whole empyreumatical; it is therefore to be kept moving with a stick till it is ready to boil, whereby the lees will be equally mixed among the liquor, and the great heat, by its motion, prevent the separating of the thicker parts from the thinner: and thus all the spirit may be advantageously obtained both from the liquor, and the lee, without danger of burning. And if the fermented liquors be suffered to rest for some time before distillation, there will be less danger of their boiling over; but when committed to the still, as soon as the fermentation is over, the remaining force of the late fermentation often carries up the boiling liquor with violence, and so disturbs the whole operation; for which reason the operator must proceed cautiously at first.

26. The following particulars tend to prevent burning. (1.) The sides and bottom of the still may be smeared over with some unctuous matter before the liquor is put in. (2.) The whole may be kept continually stirred till the heat begins to mix it, and thus by the motion prevent the thicker part from falling and fixing to the bottom. (3.) Nothing more effectually prevents this burning than the previous boiling of a little water strongly in the still; and whilst this is in hand, immediately pouring in the liquor to be distilled; for the hot vapour, filling the cavity of the vessel, prevents the fermented matter from sticking to the sides.

27. If, according to this direction, the whole fermented matter, with its flowers, clear liquor, and its lees, be thoroughly mixed together, and then distilled, a perfect spirit will be obtained.

28. When the matter is almost ready to boil, its first violence is to be guarded against, for which purpose one third part of the still must be left empty, and the mouth of it covered with a thin linen cloth to be kept fixed by the head; then the fire is to be so regulated, that one drop of liquor may just follow another, by which means the distillation will proceed with safety; and being kept up for some time in this manner, it may afterwards be somewhat increased with caution, so as commodiously to raise all the spirit; but the thinner and clearer liquors, such as mead, wines, and old malt-drinks, do not require so much caution; but all mealy subjects, distilled immediately

mediately after fermentation, require the utmost care : the former therefore may from the first be distilled, so as that the spirits may run in an almost continued stream from the worm.

29. Whilst the operation is performed, in the manner above described, the liquor that first comes over proves sharp in the mouth, heating, pungent, of a particular taste, called by the name of spirituous, and extremely penetrating. It is also highly fluid, and volatile, so that few liquors are known to exceed it therein, or scarce any besides the pure alkaline spirit, the smoking spirit of tin, *Glauber's* spirit of nitre and sea-salt, and true volatile alkaline salt. When this liquor is strongly heated by fire, it readily takes flame upon the approach of a candle, and burns nearly all away ; it occasions drunkenness, stupefaction, and the apoplexy ; but in a small dose wonderfully raises the spirits ; by its heat, it presently cures punctures, lacerations and pains in the nerves ; it preserves from putrefaction all vegetable and animal bodies that are put into it, only changes their colour a little. If a little pure sugar be dissolved in it, before it is perfectly free from all its phlegm, it makes a limpid liquor, that preserves the tenderest substances. If it be diluted with water, and applied in the manner of a warm fomentation, with a little sal-ammoniac and vinegar ; there is scarce any thing better for resolving coagulations, discussing tumours, stopping gangrenes, separating the putrified parts, and drying up the humours that run off too fast. It is called spirit of wine.

30. If when all this spirit is come over, the remainder be urged with the same fire, in the same vessels, there follows a less volatile, acetous, acid, astringent, cooling, nauseous and foul liquor, leaving at the bottom a thick feculent matter, which can never after, by any art, be brought to ferment again, nor to afford any more spirit, tho' from its thickness, one might easily expect it should ; and if this remaining mass be treated with a strong fire, it affords a fetid empyreumatic oil.

31. If all the feculent matter be dried, and afterwards burnt in a naked fire, it affords saline ashes, from whence a fixed, and somewhat alkaline, or truly alkaline salt, may be obtained ; after the same manner as under our fifth, sixth, ninth, tenth, twelfth, and nineteenth processes ; whence it is plain, that the most perfect fermentation cannot volatilize that matter of vegetables, which is fixed by burning in the fire, and which might be converted into essential salt, according to the seventh and eighth processes.

32. This is a short and true history of fermentation, delivered in a chemical manner. I have so far explained its subjects, assistants, impediments, causes, manners, actions and effects, that, perhaps, there is no other physical action so clearly and distinctly defined, and so accurately separated from all others, as this is. Hence, I presume, the reader will beware of confounding this action of nature, with any other different from it, to prevent a confusion of terms, and thence of doctrine. And thus medicine will be freed from so many and trifling fictions of the effects of imaginary ferments, wherewith the half learned chemists, have disturbed and oppressed it. Thus the physical history of animals and fossils will be purged from so many opinions of fermentations ineffectually introduced, as being an operation never performed

The Practice of CHEMISTRY.

performed there. It seems only to begin in the first passages of animals destined for the production of the chyle, and in such creatures as are supported by fermentable foods and drinks; but soon after breaks off on a sudden; tho' in a few distempers it may perhaps be continued farther, even thro' the intestinal cube. The great masters in alchemy have also been too licentious, and wandered too wide from one or two resemblances, till they declared that metals fermented. Every operation in arts should be strictly limited by its individual properties, which constitute the peculiar nature of the action; for thus, upon barely hearing the mention of the effect, the attentive mind immediately understands what ought certainly to happen. Let us use the utmost caution to prevent confounding this operation with effervescences, ebullitions made by the fire, or the putrefaction of vegetables or animals; of which hereafter.

P R O C E S S XLIII.

Meal and malt mixed with a proper quantity of water, and fermented.

HAVING laid down the general doctrine of fermentation, we proceed to deliver certain examples, that shew the manner wherein nature and art proceed. There are therefore two ways of working, the first whereof prepares a drink, or wine, from corn, and thence a spirit of wine; the other directly produces a spirit from fermented corn, as it is usually produced from malt liquors.

The first manner is this; they pour hot water upon ground malt, mix them well together, and let them stand to infuse warm for three or four hours, by which means the malt impregnates the water with its flowery part, contrary to what the meal of natural corn would have done. The infusion, being now drawn off from the remaining malt, is boiled up to the requisite thickness; this decoction has an emollient, laxative, purging, cooling, antiphlogistic virtue. If, after it is cooled, and set in a warm place, a proportion of strong yeast, or lees, be added to it, and the vessel be kept open at top, there arises a violent fermentation, which being finished, and the liquor directly strained cold, thro' a cloth into a cask, that is afterwards closely bunged down, it thus becomes excellent malt-drink; but to make it keep the longer, a certain quantity of the bitterest herbs is boiled therein, which prevents its turning sour. If the decoction be made sufficiently thick by boiling, moderately impregnated with the bitter plants, perfectly fermented, and kept in well-closed casks set for a long time in a vault, and be afterwards distilled, there first comes over as excellent a spirit of wine, as can be obtained by art from any real wine; as proving extremely fragrant, and without any ungrateful odour. And this I have by experience found, that such a kind of malt-drink scarcely differs from the most generous wine; and have wondered, that in all the ages, of which we have any notice, it should have been known and

and used. *Diodorus Siculus* (a) says, that King *Osiris* taught a way, where wines are wanting, of preparing a drink from barley, not much inferior to wine in fragrance, and pleasantness. *Herodotus* (b) speaks of a beer, or wine made from barley. *Tacitus* (c) of barley or corn steeped or prepared, so as to resemble wine. And *Actius* (d) speaks of barley steeped till it sprouted, then dried along with its sprouts.

The same operation is performed in the common method thus. Take fourteen pounds of the flower of malt, and seven pounds of rye flower, mix them very well together, for a considerable time, with hot water, till the liquor becomes moderately thin; then pour it into an oak cask, and set it into a wooden chest, as formerly mentioned, that it may be kept in a warmth equal to that of summer; it will thus ferment strongly, and should stand till the crust form'd at the top, during the fermentation, be fallen to the bottom; then close the vessel, and leave it so for some time, by which means the liquor above will be clear, and tartish; whilst a large mealy mass will be found at the bottom, tho' not clammy, but fit for distillation.

PROCESS XLIV.

Honey diluted with water, and fermented.

DILUTE honey with such a proportion of rain-water, that the solution may support a new laid egg on its surface; this is called hydromel. Fill an upright cask with it, so as to leave the tap-hole, which is now at the top, open; place the cask in the wooden chest, and keep it constantly heated to seventy degrees. The liquor will soon begin to ferment, with all the signs of fermentation; let it continue thus till the operation is entirely over, when the liquor will have a sweet spirituous taste, and is to be kept in a close vessel, under the title of mead, or metheglin.

PROCESS XLV.

Malt and meal fermented, as in the forty-third process, afford an inflammable spirit, and a vinegar, by distillation.

POUR a pint of boiling water into the still, light up the fire, that the water may continue strongly boiling, then pour in the malt and meal fermented according to the forty-third process, after they have by shaking been well mixed together, leaving a third part of the still empty; the fire is now to be increased, and the matter kept frequently stirring with a stick, to prevent the grosser part from adhering to the bottom, and to continue the mass well mixed. When almost ready to boil, clap on the

(a) *Diodor. Sicul. l. i.* (b) *Herod. in Euterp. lib. 2.* (c) *Tacit. de morib. German.* (d) *Act. Cinn. &c.*
 Vol. II. R still.

The Practice of CHEMISTRY.

* still-head, and carefully regulate the fire, so that the head may grow thoroughly hot, and the spirit may distil sufficiently quick thro' the worm; and thus a limpid, thin, spirituous liquor will be obtained. As long as this continues to run, let it be kept separate under the title of malt or corn-spirit: after all this is come over, there follows a tartish, unpleasant, nauseous, white liquor, which has nothing spirituous, or hot to the taste, and if farther urged, begins to smell fetid.

* This first liquor is that we before described, in the history of fermentation, under the title of spirit, produced by fermentation.

PROCESS XLVI.

Mead prepared by fermentation, according to the forty-fourth process, affords an inflammable spirit, and a vinegar, by distillation.

* TAKE mead prepared according to the forty-fourth process, and long kept in a close vessel; and distil as above: tho' as this is less flatulent, or explosive, it requires less caution than the former. An excellent spirit of wine will first come over, not to be distinguished from that of real wine; and the time it continues to run must be observed, that this spirit be kept separate. When it is all come off, if the receiver be changed, another watery, white, ungrateful liquor will follow.

The use.

These two processes afford examples of the distillation of spirits from fermented liquors, together with the proper cautions required. The gross, mealy matter remaining behind, as also the remainder of the mead after the spirit is drawn off, still contains something nutrimental; and the case is the same in beer. But if this matter be artificially treated, according to the process of fermentation, it cannot be made to ferment again, but it will grow sour and vapid, without turning vinous so as to afford fresh spirit; and thus it gradually corrupts more and more.

PROCESS XLVII.

The rectification of the spirituous liquors produced by fermentation.

* TAKE any fermented spirits that have been once distilled, and draw them over again, leaving one third of the still empty, and observing to regulate the fire so as to make the liquor gently boil, or a slender stream to run from the worm: and thus a limpid, thin, and fragrant liquor will first arise, having the taste of spirit. Let the receiver be often changed, in order to taste whether the same spirit continues to come over, and keep on working so long as it does. The spirit, thus produced, is to be carefully kept separate,

‘ separate, and put up in a close glass, under the title of rectified spirit of wine; and here it is certain, that what comes off first is always the best. When therefore the tartish, white, and more aqueous liquor begins to come, this must be kept separate under the title of phlegm, and not mixed with the former; it usually comes over in great plenty, and contains but little spirit. There yet remains, at the bottom of the still, a gross, opaque, unctuous, acid liquor, of an ungrateful smell; but as to the rest perfectly aqueous, in respect of spirit. If this liquor was left upon the distillation of pure brandy, it is always red, and has a somewhat austere taste; both the colour and the taste being principally owing to the wood, or cask, in which such brandies are usually preserved; for they extract the resinous and oily parts from the wood, and have not this colour, taste, and odour, when first distilled, but are then perfectly pellucid; and acquire these properties by their lying in the cask, and lose them again by rectification.’

The use.

Hence we understand how these spirits may be so purified, as to be procured almost alone, or unmixed; and the oftner the rectification is repeated, the more pure they become; as always leaving behind some watery, acid phlegm, upon each repetition; whence they constantly become more pure and simple, tho’ they still retain some water.

Hence we learn also, that brandies always consist of some different kinds of parts; for they contain a pure spirit, the product of fermentation, which we shall shew how to exhibit alone in the following process. Secondly, a pure water, which may likewise be separated from them alone, as in the two following processes. Thirdly, a certain acetous fermented acid, which also rises in the first distillation of spirit of wine, and remains strongly cleaving thereto, but is exactly separated from it in the following forty-ninth process. Lastly, a small quantity of a certain ill-scented oil, which always manifests itself, when rectified spirit of wine is poured upon dry fixed alkali, or when the spirit is drawn from that salt by distillation; whence it has happened that chemists, sometimes, little attending to these particulars, and often employing the common spirit of wine, have met with phænomena they did not expect: and these phænomena are often unjustly attributed to the spirit; whilst they are rather owing to the other things mixed therewith. Such phænomena may be owing to other causes; but the spirit is to be ascribed to fermentation alone. Some considerable chemical authors, observing that an acid almost constantly accompanied these spirits, have wrote that the spirits themselves were acid, and generated from an acid. But if the thing be rightly considered, it may perhaps appear otherwise; for when these pure spirits are distilled from fixed alkaline salt, they are totally deprived of all manifest acidity, yet are still excellent and genuine. I allow they are only produced from vegetables, that first turn acid by fermentation, but not that the spirits themselves are acid, though produced from a tart substance; whence we cannot truly say of them, that they are either acid, or alkaline, but of their own peculiar nature. And the spirit, rectified to the utmost perfection in this manner, will still remain compounded.

PROCESS XLVIII.

Alcohol produced from the spirits gained by fermentation, according to the forty-fifth, forty-sixth, and forty-seventh processes, without addition.

LET any spirit obtained by fermentation, especially such as has been once rectified, be distilled with a gentle fire, from a tall narrow glass-body, in the little furnace described in the chapter of furnaces, till one half be come over: and here the heat should not be raised higher than a hundred degrees. Let the half, which first comes over, be distilled again from a clean vessel, and repeat the operation till the half remaining in the glass-body appears as strong as that which came over. A spirit, thus obtained, is that usually called alcohol of wine, and is accounted perfectly pure, without any foreign mixture, even so much as of phlegm. The ancient artificers used the same method but in different furnaces (a). But the exactness of later chemists has found, that some water still constantly remains concealed among it; whence many experiments, requiring the use of perfect alcohol without water, have proved unsuccessful: but as the labour of procuring such a spirit was extremely tedious, industry has discovered a shorter way of obtaining alcohol in purity.

A kind of furnace was made for a bath-heat, that could not admit a greater heat than of 214 degrees; and herein a large still was placed, and common spirit of wine poured into it, so as to fill two thirds thereof; the still was now fitted with a head rising in a tall, upright, slender pipe, which, bending at the top, came down and fitted into the worm. The distillation, here, is so performed, that the water of the bath coming to boil, makes the spirit of wine boil stronger; whence the spirit alone being able to rise so high from the fire, and thro' so slender a pipe, continues to distil as long as any remains in the liquor; and when all the spirit is come over, the phlegm will not rise, but the distillation then immediately ceases. And thus, at a single operation, we may, in the compass of two or three hours, obtain as much spirit as by the former method we could in almost a month: and therefore no chemist can be without this furnace, who requires a large quantity of alcohol in his operations (b). Yet upon carefully examining the matter, I find that even thus a little water will still remain mixed with the alcohol, being in the distillation raised therewith. Hence I have repeated the operation, and re-distilled the alcohol by itself in this same furnace, whereby I obtained an alcohol that appeared pure, almost in every respect, tho' even this contained some little water. Whence I conceive, that the spirit, by this method, can never be perfectly separated from the phlegm, tho' it is but a very small quantity that is here left behind.

(a) See the collector of the chemical menstrooms, concerning the method of procuring the philosophical spirit of wine.

(b) See the construction of this furnace, in the chapter of furnaces.

After

After this therefore I took the alcohol prepared by distillation in this furnace, and half filled the still therewith; then adding half a pound of pure decrepitated, hot and dry salt, I put on the head, carefully closed the junctures, and left them thus together for twelve hours, in a heat so small, as by no means to make the alcohol boil. Then I distil'd off the spirit, and kept the first two ounces apart, because some little aqueous vapour might happen to lodge in the pipe of the still or worm; and this alcohol of the first running will easily wash it off. I afterwards received two thirds of the following alcohol in a pure dry glass vessel, and kept it perfectly well stopped; then I drew off the remainder as before, and kept this by itself: there remain'd a moist salt in the still, which had attracted the water from the alcohol, and held it so down, that it could not rise by the heat of boiling water, so as to come over with the alcohol. And the salt thus prepared never changes the alcohol by communicating any thing thereto; because it is first decrepitated, and employed hot: and by this means I can in this furnace readily prepare a perfectly pure alcohol for all chemical uses.

The use.

1. The alcohol thus perfected, is the lightest of all fluids next to the air, extremely pellucid, thin and simple, totally inflammable without smoke, and without leaving any fæces behind; it has no disagreeable scent in the burning, remains the same after distillation, is very expansive with heat, easily boils over the fire, is of a very grateful odour, and of a particularly grateful taste; it instantly coagulates all the juices of the body, except pure water and urine; it hardens the solid parts of the body, and preserves both the solids and fluids from putrefaction, or spontaneous resolution; it preserves the bodies of insects, fishes, birds, and other animals, suspended in it, perfect for ages; it mixes almost uniformly with water, vinegar, any acid liquors, oils, and pure volatile alkaline salts; it dissolves gummy and resinous bodies: whence we are acquainted with no liquor, either natural or produced by chemistry, that will mix with more bodies. It is in particular an excellent vehicle to the presiding spirit of vegetables, as by means of alcohol, it may commodiously be extracted from its own body, and be used for medicinal and other purposes. The capital chemists, who are accounted adepts, are supposed to have shadowed out the preparation of the secret of the philosopher's stone in the artificial preparation of this perfect alcohol: and certainly this alcohol owes its origin to fermentation alone, and cannot otherwise be prepared.

2. In the live human body it wonderfully raises, gratefully affects and stirs the animal, natural, and vital spirits, the nerves and the brain, by its odour, taste, and exhalation; whence it increases and enlarges the strength, the sense and agility; and thus by various degrees, at length, occasions drunkenness, which both comes on, and goes off suddenly. It instantly coagulates the blood, the serum, and other juices; whence, when imprudently drank, it is said to have instantly killed the drinker. Externally applied, it dries, strengthens the vessels, and coagulates the juices in them, where it reaches, by insinuating itself. It in a moment dries up and contracts the extremities

ties of the nerves, which it touches, and deprives them of all sense and motion; whence it appears how imprudently, and often unsuccessfully, alcohol is used, either pure or impregnated with aromatic spirits, and heated, for a fomentation; or rubbed into the parts externally, for chirurgical purposes, with the addition of camphire, or the like dissolved in it. Caution must therefore be here used; for instead of the specious titles of vivifying, heating, restoring mobility, resolution, and dissipation, the effects will be such as we have above described. In wounds, likewise, and in ulcers, the application of pure alcohol has the same effect, by coagulating, drying, and burning up the nerves, which it eases of all pain, but at the same time destroys their use. It instantly stops bleeding by contracting the vessels, and coagulating the blood it touches, but then also it has the effects above mentioned; and hence it becomes a sudden, and often a powerful remedy, in these cases, tho' always attended with danger.

3. Hence we understand what the effects of pure alcohol are upon the parts of animals, and plants, suspended in it; for if they contain any thing oily, the alcohol will dissolve it, and extract it from the matter, which therefore becomes shrunk, diminished, and often wrinkled: and hence the prepared parts of animals often appear thus changed. Aromatic flowers, leaves, and roots are affected in the like manner; but small birds with their feathers on, and little animals covered with hard scales, are exactly preserved by being plunged in hot alcohol; because the shrinking, if any should happen here, is not so easily perceived; and when they have been steeped for some time in pure alcohol, so as to be thoroughly penetrated therewith, and then dried in a slack oven, and afterwards suspended in glasses close shut, so as perfectly to exclude the external air, they may thus be preserved for ages, to the unspeakable advantage of natural and medicinal history, because they will thus leave us specimens, whereby the things may be known.

4. Since therefore chemists and other artists require the purest alcohol on numberless occasions, so that if the least drop of water remain in it, the experiment would fail of success, we ought to have some certain marks whereby to discover when this alcohol is perfectly pure. These marks are chiefly the following, (1.) If the alcohol contains any oil dissolved therein, it immediately turns milky upon the addition of water, and lets go the oil. (2.) If it contains any acid, when a little of the alcohol is mixed with the spirit of *sal-ammoniac*, the effervescence thereupon will shew, that an acid is present, otherwise a simple coagulation will remain; and if any thing alkaline be concealed in the alcohol, this will be manifest by the effervescence that the addition of an acid will occasion. As for other salts, they are seldom contained in alcohol. (3.) It is more difficult to discover whether any water be concealed therein; whence the chemists have invented certain ways of trying it: the first whereof is repeated distillation, from whence they expected to obtain the spirit pure without phlegm: but I have observed, that I could never by this means obtain it so. A second way, therefore, is to fire some of the alcohol heated in a spoon, and suffer it to burn in a still place, where no wind is moving; and if after the burning, no moisture remained in the spoon, they pronounced the alcohol pure. But being made more cautious by

by the means of other experiments, which we shall soon relate, they observed that the water also, concealed in the alcohol, might at the same time, by the action of the flame, be carried into the air; and consequently, that this was a fallacious proof. In the third place, therefore, they took dried gunpowder, and laid a little of it in the bottom of a dry spoon, then pouring the alcohol upon it, they heated it, and set it on fire, and suffering it to burn out in a quiet place, if at last the gunpowder became dry, and took fire, they judged the alcohol to be pure. But this trial also is apt to deceive as well as the former; both which, tho' they shew the alcohol contains but little water, yet do not shew that it contains none: therefore in the fourth place, the surest trial of all is to take a round chemical four or six ounce vial, with a long and slender neck, and filling two thirds thereof with the alcohol, add thereto a drachm of pure dry and hot salt of tartar, shake them well together, and hold them over the fire, so that they may heat a little less than suffices to make the alcohol boil, and if when thus heated and shook they leave the salt of tartar perfectly dry, we may be sure that the alcohol contains no water, or if any, not to be discovered by any experiment hitherto known, unless by the water collected from the flame of alcohol entirely burnt, of which experiment we have sufficiently treated above (a). At least when I have mixed this alkaline salt with alcohol, allowed to be pure, I have immediately discovered whether it contained any water; for upon taking alcohol that would burn entirely away, and fire gunpowder, yet salt of tartar being added, and growing moist therein, presently shewed that such alcohol contained water. Again, upon adding a drop or two of water to the alcohol, wherein the fixed alkali had long remained dry, the salt immediately grew moist, and appeared to run unctuous upon the sides of the vessel. Hence therefore the peculiar nature of alcohol is sufficiently determined by its own invariable properties; especially if we add, that such alcohol distilled in a glass alembic gives no signs of itself, as neither like water appearing in moist drops, nor like good spirit of wine running in veins, but remains invisible; which was known to the ancient chemists, as appears by their writings. And this is the ultimate limit of fermentation; because this alcohol can scarce be further perfected or changed.

PROCESS XLIX.

Alcohol prepared with alkalies.

- **B**ECAUSE a large quantity of pure alcohol is often wanted of a sudden,
- when the chemical apparatus is not at hand, and when it is not detrimental if the alcohol should contain any fixed alkali; the industry of the
- chemists has discovered this method. Take a clean glass-body, containing
- common spirit of wine, and add thereto one third of its weight of pure
- and dry pot-ash, which immediately falls to the bottom, shake the glass

(a) See the articles, Fire and Menstruums.

and the salt immediately grows moist, and begins to dissolve at the bottom, whilst a thin, red liquor floats above it: the more the vessel is shook, the more liquid the lower part of the salt becomes, and the more distinctly separated from the upper liquor; nor is it ever possible to mix them together, but upon resting they will immediately separate into two distinct masses. The less water the spirit contained, the more there will be of the upper liquor, and *vice versa*.

Let these liquors rest for some time, that they may exactly separate from each other, then pour off the upper liquor, by a gentle inclination of the vessel, into another clean and dry vessel; with care to prevent any of the other liquor from falling in. Have in readiness another parcel of fixed alkaline salt, well dried at the fire, and put it hot into the glass-body containing the former spirit, now decanted, and deprived of its water; shake them together in the glass kept shut, and the salt that was put in dry will again become somewhat wet; continue to shake them so long till the salt appears to dissolve no more, but a transparent red liquor floats above it, which will be obtained the purer, the drier and hotter the alkaline salt was, and the longer the shaking was continued. After this, pour off the liquor into a tall and dry chemical vial, and put to it a little extremely dry, pure and hot fixed alkali; set them together in a place heated to a hundred degrees, and frequently shake the vial; if the salt now remains perfectly dry, the alcohol will be pure, but of a red colour, a mixed taste, and a somewhat ungrateful odour; it will also give manifest signs of its containing an alkali by its lixivious taste, and making an effervescence with acids. In this operation there always appears some fat oil, which separates itself, either from the spirit, or the pot-ash, or perhaps from them both; and this oil has an unpleasant smell: the fixed alkali likewise here employed, changes its nature, and by uniting with the acid contained in the spirit, at length becomes a compound, and somewhat volatile salt. Hence I have found that this salt being several times used for the same operation, and each time dried again, at length changed as it were into the nature of *terra foliata tartari*; or at least became unfit for farther service as a fixed alkali: whence we have a confirmation of what was above said, of the nature and parts of common spirit of wine. If the alcohol, thus prepared, be once distilled with a gentle heat, in a glass vessel, it will be obtained sufficiently pure, and not unfit for all the operations that require a perfect alcohol; somewhat however of an alkaline nature remains in it, and may be destroyed by carefully adding a few drops of the oil of vitriol, before the distillation, till no more effervescence appears, after which the alcohol will be obtained pure by distillation.

The use.

Hence we learn that the procuring of pure alcohol proves more difficult than is commonly thought; because somewhat acid and aqueous remains intimately mixed with it in the distillation: and by using of fixed alkali, this also closely unites with the spirit; whence we need not wonder, that many elegant

elegant experiments, requiring the use of simple alcohol, should so seldom succeed. It is also manifest, that fixed alkali will fit the alcohol for certain experiments, either because it separates the water, acid, and oil; or because it adds something of its own alkaline nature, and so increases its dissolving power. All these particulars, therefore, are to be regarded before we can determine of the success or failure of any experiments wherein alcohol is used. Chemistry, therefore, having produced alcohol, is come to its utmost limits in this particular; as being unable to perfect the production farther, resolve it into more simple parts, or even to change its nature. Upon a careful examination I found, that the most limpid spirit of wine, rectified in the common manner, by one distillation, and poured upon pure salt of tartar, divides itself into two parts, sometimes nearly equal; one whereof is pure water, and the other pure alcohol, as is sufficiently known; but I never could find, upon making many experiments, that true simple alcohol, united with pure fixed alkali, would mix one half, or its oily part, with a saline alkaline substance in form of a balsamic soap, called the *Samech* of *Paracelsus*, and leave its other half mere elementary water. This however is asserted by the great *Helmont* (a), and indeed it succeeds in the manner I mentioned above; but not as the followers of *Helmont* assert, viz. that he here joined the sulphur of the wine with the fixed alkali: for in my experiments the water joins with the salt, and rejects the alcohol so long as any water remains therein; whereas they say that the oil of the alcohol unites with the salt, and rejects the water. But more of this subject in our *eightieth* process, where some laborious experiments, performed to this purpose, will greatly illustrate the matter; and nothing more of this kind is here required.

PROCESS L.

The origin of vinegar.

HAVING seen the effect of the first fermentation, viz. the production of alcohol, we come next to consider the production of the second, viz. vinegar, which can never be had genuine, without a previous, and indeed a double fermentation; for wine must first be made, before vinegar can be procured. And again, every wine is disposed to become vinegar by art, that is, if the wines be mixed in, and stirred with their own lees, flowers, and tartar reduced to powder, as also the acid and austere stalks, skins, husks, and leaves, that contain a tartarous salt, and the whole be set in a warm place, contained in a wooden vessel, especially such as has been seasoned with the fume of vinegar, and in a place also abounding with a vapour thereof: for thus the wine begins a new fermentation, and produces a considerable degree of heat, in which respect the acetous seems to differ from the preceding vinous fermentation. And if the vinous species should be too long continued, the wine will grow sour and flat, but never become good vinegar, to make which requires a particular and exact operation.

(a) Page 58, 86.

The remote matter, therefore, of acetous fermentation is every vegetable subject fit for vinous fermentation, provided it be first properly changed into wine by means of the vinous fermentation: but the immediate subjects for preparing of vinegar are wines of all sorts; this rule being observed, that the strongest wines afford the sharpest vinegars, and *vice versa*.

The proper ferments for promoting this operation are chiefly these, (1.) The lees of tart wines. (2.) The lees of vinegar deposited in the old casks, especially, if saturated with the sharpest vinegar. (3.) The tartar of acid wine reduced to powder. (4.) Vinegar itself perfectly prepared, and brought to a high degree of acidity. (5.) Old casks which have long lain filled with the sharpest vinegar, so as to become penetrated with the sharp acid thereof. (6.) The frequently repeated mixture of the lee with its own wine. (7.) The stalks, husks, and skins of cherries, currants, grapes, or the tendrils, and the like parts of the vine, that are acid and austere. (8.) Bakers leaven, after it is turned acid. (9.) All the compositions of the former, especially with the addition of keen aromatics; for then the vinegar, hence produced, will become exceeding strong.

Glauber has long ago exactly described the history of the operation in his writings against *Barner*, and it was afterwards published in the Philosophical Transactions. The method in short is this.

‘Take two large open vessels, made in the manner of common hogheads, in each of them place a wooden grate, within a foot of the bottom, as they stand upright; upon these grates first place a moderate layer of the green twigs, or cuttings of the vine, and upon this the stalks of the grapes, without the stones, till the whole pile reaches within a foot of the tops of the vessels, which are to remain open; then fill one of these vessels with wine to the top, and only half fill the other; then with liquor drawn out of the full vessel, daily fill up that which was only half full before, and do this alternately, without ever leaving a full vessel above twenty-four hours. Thus on the second or third day there will arise in the half filled vessel the motion of fermentation, with a sensible heat, which gradually increases every day; and in the full vessel, the motion and heat is at the same time checked, so as almost to cease upon that day: and thus fermentation and heat cease and renew alternately, first in one vessel, and then in the other. The operation must be continued, till at length the heat is extinguished, and the motion stopped in the half filled vessels; which is a sign that this acetous fermentation is perfectly finished. The vinegar thus prepared is to be kept in casks closely stopped.’

The use.

The hotter the place is wherein the vinegar is made, the sooner the operation is performed; and in *France* it is finished in fifteen days in the summer, but in winter, and in a cold place, it requires much longer time; and in the heat of summer, or if the place be extremely hot, the vinegar often requires to be shifted from the full vessel into the half full one every twelve hours, otherwise such a heat and fermentation would be raised in the half

filled

filled vessel, as to dissipate the volatile spirit of the wine, not yet sufficiently fixed, before it was fixed and changed into the acid spirit of vinegar; and thus the vinegar would become vapid, and no way like that which is found and good; and for this reason the half filled vessel is always kept close stopt with a cover, that the ebullition of the liquor may be checked, and that the spirit, being kept in, may the longer and more powerfully act upon the austere body, and be entangled by its re-action. And these covers are to be made of the same wood; but the full vessel is always left open, that the air may have free access to change the liquor.

This is the second fermentation that tends to, and terminates in the making of vinegar; which is unjustly taken for a liquor produced after the loss of the spirit of the first fermentation; for in that case the liquor would be a vapid thing, and not vinegar: but the more generous and spirituous the wine is, the better vinegar it affords in this operation, and the weaker, the worse. And hence good malt-liquors, treated in the same manner, make excellent vinegar; and the same holds true of rich *Spanish* wine. We must here observe that this fermentation, which converts wine into vinegar, is attended with a considerable heat, whereas fermenting must, in the time of the vintage, is scarce warm, and fermenting beer, notwithstanding its violent motion, is not so much as warm; whence it should seem that heat is always required to generate acidity. Milk and meats prepared of bread, flower, &c. require a heat of some kind or other, to turn them sour; the violence of the fire turns the neutral bodies of nitre, salt, and sulphur, into very strong acids. If we consider this, we shall see that almost every thing requires its peculiar heat.

Another thing to be here considered is, that whilst wine acquires the nature of vinegar in the manner above described, tho' the wine was thin and limpid, it deposits an incredible quantity of a gross, fat, oily, or soapy matter, which all around gradually grows to the sides of the cask, and the skins and twigs employed. From whence should this proceed? There are no signs of it in the wine, the twigs, or the rape; yet it is thus generated from the wine, because if washed away, more is produced by the wine; and this unctuous gross matter ought to be removed once a year, otherwise the wine put into the casks would not be changed to vinegar, but into a corrupt, gross, unctuous liquor, unfit for any use. Therefore all the rape, now turgid with the ferment of the vinegar, is suddenly to be washed from this unctuous matter, by passing water quick thro' it, lest by remaining long in the water, the acid virtue of the rape should be drawn out; so likewise the grate, the sides and bottom of the vinegar casks, are to be cleansed with the same caution, and again fitted for the operation as before; and thus they serve again, till by a long continuance of converting wine into vinegar, the same unctuous crust shews, that the wine does truly throw off an oil, whilst it passes into vinegar; and that the acetous ferment does remain in the cask, the grate, and the rape: whence this power becomes very great in the old casks of this kind, which, together with all the parts belonging to them, at length become a kind of sponges full of vinegar.

We must, lastly, remember what was observed above, that alcohol prepared from old strong beer is undistinguishable from that afforded by the best wine; and the same holds true of vinegar, which, being made from the strongest old beer, proves as good, pure, and useful for any purpose, as that made of the best wine. Nor can any difference be easily found betwixt them, unless so far as the bitters employed in making the beer may give it a different taste and colour, and somewhat alter the nature of this from that made of malt alone: and hence we may be sufficiently certified of the action of this second fermentation, which, when perfectly performed, is the production of good vinegar.

That this action, however, may be the better understood, we proceed to consider what vinegar is; and we shall find it a vegetable, acid, penetrating, somewhat unctuous, and volatile fluid, produced from wine, by the action above described, the first part whereof that comes over in distillation is truly acid, and no way inflammable, but like water quenches fire and flame; which wonderful properties accurately distinguish vinegar from wine. Wine is prepared by the first fermentation directly from vegetables, and vinegar by a second fermentation from what was wine before. The first part that comes over from wine by distillation is readily inflammable, but the first part obtained from vinegar by distillation extinguishes flame like water; and therefore there is a particular difference between them. Some of the most skilful among the chemists have said, that vinegar is the volatile tartar of wine, because tartar is the most acid part of wine, tho' not volatile; and vinegar a conversion of wine into an acid that is volatile: and again, because wine generally deposits a tartar, but vinegar none, tho' it stands long, whilst yet being deprived of a great part of its oil in the making, and so become more acid, it should seem so much the more disposed to generate tartar. It is true, that what remains at the bottom, after the distillation of the vinegar, seems to resemble tartar, but yet, upon due examination, it will appear very different from it, as we shall see in the fifty-first process. But it is of great moment to chemistry, medicine, and all philosophy to understand the nature of this vinegar. And, (1.) it is a liquor already described by its characters, to which we may now add, that it is a volatile, oily, acid salt; for its oil, tho' wonderfully concealed under a thin and hungry acid, will hereafter be manifested by many evident experiments, especially under the seventy-sixth, and hundred and seventy-third processes. This composition is extremely useful, as resisting putrefaction, which is so common and so dangerous to the animal juices, and at the same time has its acrimony mitigated by the oil united with it. It is also so penetrating, as without a separation of different parts, to pass expeditiously thro' the densest substance, without losing its virtue: nay it will freely pass almost thro' the whole body, except a few small vessels, and therefore may be distributed into all the larger, and exercise its proper virtues therein, especially as they will be there excited by the vital motion and natural heat. It also easily mixes with all the juices of the body, not excepting even oils themselves; and by means of its thinness and disposition to mix, it produces many effects in the body. It has an extraordinary cooling virtue in fevers that arise from an acrimony
of

of the bile, or any alkaline salt, or putrid matter generated in the body; as likewise from the bites of venomous creatures; and allays the thirst occasioned thereby: whence *Dioscorides* and *Hippocrates* have commended nothing more highly in these cases, than a mixture of vinegar and water, especially when mollified by the addition of honey. And surgeons know of nothing more efficacious in external disorders, such as the *erysipelous* inflammations, and putrid ulcers; and for the cure of venomous bites, there is nothing more effectual, than this liquor of honey and vinegar, as we remarkably find in the bite of a mad dog. It is so opposite to drunkenness, that whereas spirit of wine is almost the only thing which occasions that disorder, the spirit of vinegar removes it. Nay, a person almost dead drunk by the abuse of spirituous liquors, may be brought to himself by the drinking of vinegar; so that nothing seems more fitted to move the spirits, and excite the nerves, than this. When I have often endeavoured in vain, by elaborate chemical productions to relieve persons in weakness, faintings, lethargic, drowsy, and vomiting disorders, I have at length effected it by means of vinegar, applied to the nose and mouth, or received into the stomach; and what is scarce to be credited without trial, I have often herewith relieved convulsive, hypochondriacal, and hysterical disorders: and as for actual corruptions of the juices, gangrenes, and mortifications, it is so serviceable in these cases, as not to have its equal: and this I openly declare upon experience. In short, we see that when the violent heat of autumn has already begun a putrefaction in flesh or blood, they may still be preserved pure and uncorrupt, by washing them with a large quantity of vinegar. I also attribute an attenuating virtue to this liquor, contrary to what is done by some others; for if mixed warm with the blood, or its serum, it does not coagulate but dilute them, without producing any thing grumous, but gently resolving coagulations. And hence it proves so beneficial in burning fevers, the plague, small-pox, measles, and the like, where, upon dissection, coagulations have been so often found: vinegar, likewise, is the principal remedy, when alkaline, volatile salts are in such cases used very unsuccessfully, because they increase the velocity of the blood by their stimulating virtue, and consequently its density. The famous *Sylvius*, if not the author, at least a great admirer of the volatile, oily salts, depended upon vinegar, as a preservative from the plague, and safely visited his patients sick of that distemper, after having prepared himself by drinking an ounce or two thereof: but having once omitted it, he was presently seized with a pain in his head. I am not acquainted with any more certain sudorific; for when diluted with water, or drank alone, it strongly promotes sweat, even in the plague, and the most malignant distempers, where other remedies will hardly answer. (2.) This vinegar seems to be generated by a combination of the inflammable spirit produced in the first fermentation, along with a certain acid, somewhat more fixed, that lay concealed in the wine; for that this spirit is not here lost or destroyed was shewn above. It therefore deserves to be considered, whether that spirit be not in the second fermentation united with the tartar, or the essential salt of the wine. The spirit of the wine appears to be here converted into the perfectly altered

altered nature of the vinegar; and if so, perhaps, this is one way commonly known, whereby the matter of alcohol is truly changed into another thing. (3.) Perhaps, the essential salt of the wine, by this means, becomes an admirable tartar; for the tartar is wholly consumed in making the vinegar, whilst, at the same time, only a viscous oil is separated from it. For if bright *Rhenish* wine be put up fresh into a clean cask, it will produce much excellent tartar; whereas the same wine, being converted into vinegar, will afford no tartar, tho' thus kept for a very long time; and yet, as was before observed, in this second acetous fermentation there appears to be nothing produced, or deposited, that any way resembles tartar, but only the viscous oily matter we speak of, which is very different from tartar. (4.) In the distillation of wine an inflammable spirit rises before the water; but in the distillation of old vinegar, the watery part comes over first, and afterwards an acid spirit, which is always the more acetous, the longer the distillation is continued. Whence it appears that the first fermentation renders its production volatile, but the second rather fixes its production. The action of fermentation is surely wonderful, as it prepares a sharp wine from a sweet must, and alcohol from a substance that contained none before; and again, of a sweet thing generates an acid, and from the matter of alcohol obtains a thing of a very different nature. (6.) The things that promote this acetous fermentation are, 1. A considerable warmth; 2. A free admission and even admixture of the air; 3. A motion, and repeated shaking or stirring together, in the open air; 4. The addition of the keener aromatics in the fermentation.

The things that hinder this fermentation are all those mentioned under the same title, in the history of the first fermentation, excepting that concessive motion is here serviceable, but in the vinous fermentation prejudicial. And thus we finish the whole history of fermentation both vinous and acetous.

PROCESS LI.

The distillation of vinegar into an acid water, an acid spirit, an extract, a sapa, a tartar, and an oil.

DISTILL old vinegar, prepared from the best wine, in a tall narrow glass body, three fourths filled therewith, with a gentle fire, till a fourth part is come over, which will be light, limpid, and run along the glass-head in scattered dewy drops like water, not in veins like spirit. It is of a tartish taste, and quenches fire like water. If this part be again distilled in a clean body to a half, what first comes over will be almost aqueous, and is of excellent service where very gentle acids are required. All the chemists have agreed in these particulars except one; for *Vigani* has wrote that the first part which arises from vinegar in distillation is inflammable, so as to burn in the fire. To reconcile this difference, I shall here relate, that having received some vinegar directly imported from
France,

France, before it had acquired a very acid taste; and directly putting 20 pints thereof into a large glass retort, I patiently distilled with a very moderate warmth, and observed, that the rising vapour streamed down the receiver in oily veins, as happens in the distillation of wine; surprized hereat, I continued the same degree of heat, till dewy vapours began to follow, as happens in the distillation of water and vinegar: then examining what first came over, I found it taste like common spirit of wine, diluted with weak vinegar, and that when thrown into the fire, it flamed like spirit of wine. But having kept the same vinegar above a year in a close stopp'd vessel, and afterwards repeated the operation, the success was different; for I procured no inflammable spirit, but only an aqueous vapour of vinegar; whence I learnt, that the inflammable spirit does in time turn into the acid of vinegar, and that the taste of vinegar new made is somewhat vinous, but that this gradually goes off with age, and the vinegar becomes more sharp and acid, whilst all the former spirit is changed, and only an acid one remains; and therefore that the inflammable part is truly converted into vinegar, which is afterwards uninflammable. And hence we find, that the chemists have spoke true, and *Vigani* not false, if we understand him of new made vinegar.

I afterwards distilled the vinegar that remained after the first fourth was drawn from it, raising the fire a little, and continuing it thus, till two thirds were drawn off from the remainder; so that of four parts of the old vinegar at first employed, only one remained behind. The liquor appeared in dewy drops, of a much more acid taste, and no ungrateful odour, tho' a little empyreumatic; it also appeared more ponderous, and, when poured to the former, sunk to the bottom thereof: and this liquor we properly call distilled vinegar.

If now the fire be increased, and the remaining fourth part be distilled out of a glass retort, into a receiver that is not too cold, there will come over an extremely limpid, and highly acid liquor, so penetrating as to sweat thro' the luting; and it will hardly rise, unless urged by a strong fire, whence the receiver at that time grows very hot, and easily bursts; and no veins appear even in this distillation, and the liquor obtained will quench fire. Let the operation be continued, till only a twentieth part, or less, remains of the vinegar employed. The last liquor that comes over smells empyreumatical.

A black, gross, acid, oily, and highly empyreumatical liquor, remains at the bottom of the retort; and, if urged with the utmost violence of fire, it affords an exceedingly acid, ponderous, empyreumatical, fetid liquor, and at length an oil, of an extraordinary burnt smell; leaving a black, acid faeces behind, which, being burnt in an open fire, affords brown ashes, after it has conceived and supported a clear flame. Lastly, there remains a large quantity of a sharp alkaline salt in the ashes.

From all this it is plain, that not the least quantity of alcohol remains in so large a proportion of vinegar; that even the nature of tartar does not here continue, but that the whole is rather become volatile, except some small part; and lastly, that vinegar is entirely different from any other known acid.

We

' We have gone thro' these operations to shew the nature, composition, and resolution of vinegar; but it would be too tedious and costly to distil vinegar in this manner for common use. When therefore a quantity of it is required, the usual method is to fill three fourths of a still, tinned on the inside, with vinegar, then apply a glass-head, and so to distil by the worm, with a fire sufficient to make the vinegar boil, and first to save apart the first fourth that comes over, then again two fourths, under the name of distilled vinegar; the fourth remaining in the still may be kept till a large quantity of it is acquired, to be distilled together for preparing the strongest kind of distilled vinegar for some particular operations; but I have always found it tainted by dissolving the copper of the still, which unfits it for internal use.'

The use.

This distilled vinegar is an oily saline acid, retaining the virtues explained of vinegar in the preceding process, tho' thus rendered more penetrating, active, and volatile, as it is freed from the most sluggish terrestrial part. The sapa of this vinegar, remaining after the distillation in glass, when seven eighths have been drawn from it, is a very noble preservative medicine both for internal and external use; but by reason of its highly austere taste, it requires to be largely mixed with sugar, or honey, to mitigate it; as *Angelus Sala* has observed: this sapa is a true detergent acid soap, which is always the more efficacious the thicker it becomes, as being thus the more oily. We also learn by this experiment how strangely the different principles of things may lye concealed among one another; for who could have believed that so much oily matter remained in fined-down wine, as is thence separated in the making of vinegar? Who, in so hungry a liquor as vinegar, could have expected a black, oily, and thick sapa? Or lastly, in a liquor so clear, and so like water, as distilled vinegar, have suspected a copious oil to be lodged? Some eminent artists have also observed, that the acid of distilled vinegar, when united with the calx of lead, so as to form the substance called *saccharum saturni*, concretes therewith into a fat and tenacious kind of sweet sugar, which, when gently dried and distilled in a glass retort, affords a fat liquor, that burns like spirit of wine; so that this sulphureous matter lay concealed in the aqueous vinegar, so as again to manifest itself, or be regenerated in the operation: unless any one had rather suppose, that the combustible oil was separated from the metallic body of the lead, by the soft acid of the vinegar; and that all this combustible fluid was only of a metallic origin: which to me does not seem probable. For the acid spirit of nitre produces an austere and sweet vitriol, by dissolving lead; but this mixture does not, that I know of, afford any such inflammable liquor by distillation. And farther, if pure distilled vinegar be poured upon highly calcined salt of tartar, an inflammable liquor will be generated, as we shall shew by a manifest experiment in our seventy-sixth process. Nothing seems more strange than that the highly acid fæces of vinegar should afford an alkali.

PROCESS

PROCESS LII.

The rectification of distilled vinegar, without addition.

TAKE any quantity of the distilled vinegar of the preceding process, and distill it to a half, in a tall body, with a gentle fire: let what comes over be kept separate, as well as the remainder; the first will be light, limpid, aqueous, and less acid, but the other an exceeding sharp, acid, and more ponderous distilled vinegar.

The use.

Wine and vinegar, therefore, are very differently rectified. In wine the first, volatile part is the best, and in vinegar the remainder. Vinegar, by boiling, is rendered stronger and sharper; but wine, by boiling, sluggish, gross, thick, unpleasant and vapid. Hence it is that flesh, cartilages, bones, and skins, by long boiling in vinegar, at length resolve into a thick liquor, by the force of the acid of the vinegar put in motion, and strengthened by the boiling. And this distilled vinegar is perhaps chiefly wanted in all metallic solutions, which require a strong acid.

PROCESS LIII.

The rectification of distilled vinegar, with verdigrease.

IF plates of the best red copper be corroded on their surface, by the spirit that exhales from the husks of grapes, after pressing, and laying together to grow warm, a bluish, green efflorescence is thence produced, which, being scraped off, is to be preserved, and the plates again exposed in the same manner, so as to produce more of the same: and the several parcels, collected together into one mass, make what is called verdigrease; which is copper corroded by this spirit, and mixed with it. It can only be successfully prepared in those places where the husks of the grapes have so sharp and penetrating a virtue. This spirit, therefore, is not the spirit of vinegar, but rather of a middle kind, betwixt a crude and vinous acid by fermentation. Take of this verdigrease, which is beautifully tinged of a green colour thro' its whole mass, put it into a clean glass-body, and pour rectified distilled vinegar thereon, so as to float three inches above it; set them together in a heat of 150 degrees, and keep them frequently stirring with a stick; the spirit of vinegar will thus be tinged of a beautiful green colour. Decant the clear liquor into a clean glass, without any of the sediment, and pour more distilled vinegar upon the remaining faeces; digest, stir, let rest, and pour off as before; and repeat this carefully so long as the vinegar continues to extract any greenness.

‘ nefs. Let all the coloured liquors be kept together under the title of tincture of copper; but an incredible quantity is left undissolved behind.

‘ Let the tinged liquors be filtered thro’ paper, and distilled, in a clean body, with a fire of 200 degrees, till at length the exceeding green liquor, remaining behind, collects a skin on its surface: the liquor that comes over will be limpid like water, aqueous, and something acid. Let that which remains inspissated behind, be set to rest in a cellar, where it will soon shoot into elegant, green, transparent crystals, sticking every where to the sides of the glass, like a small crust. Let the unconcreted liquor be carefully poured off, that the crystalline crust may remain dry, and be afterwards farther dried, extremely slowly, in a very warm air, having been first carefully separated from the glass; and thus it ought to be kept to prevent its growing opaque, by too great a heat. Let the remaining liquor be again inspissated to a pellicle, again crystallized, and separated as before; and continue thus till all the true copper, contained in the verdigrease, be converted into pure crystals of verdigrease, which are now vulgarly called, in the shops, by the name of distilled verdigrease. When this is ground to a fine powder, it affords a pigment of a beautiful green colour; and if sprinkled upon a foul ulcer, it soon produces an eschar, tho’ not without pain, and entirely dries up the ulcer, whilst an inflammation arising below separates the crust: and thus inveterate ulcers are sometimes excellently healed; for it is corrosive, like the corrosives prepared from mercury and silver.

‘ A proper quantity of these crystals, being distilled in a glass retort by various degrees of fire, afford at first an aqueous liquor, which may be either kept separate, or thrown away; but the liquor that next comes over acid, unctuous, and running in veins, is to be collected separate, and preserved as a ponderous, and the richest acid, that can by any art be prepared from vinegar. And hence it is recommended by *Basil Valentine* for the dissolving of pearls; and *Zwelfer* calls it esurine vinegar; and boasting of it as of the alcahest, is thence corrected by *Tachenius*. After the operation is performed, there remains behind some powder of the corroded copper, that may again be dissolved in distilled vinegar, and brought into crystals as the former.

The use.

This fermented acid is the strongest that can be procured from vegetables, and therefore richly possesses the chemical and medicinal virtues that may be thence expected. And as therefore it raises the appetite, depraved by a corruption of the bile, or other juices, it is hence called esurine; but proves prejudicial in such cases where loss of appetite proceeds from an acid in the stomach, as physicians know it often does. This also loses its acid virtue, as others do, when mixed with absorbents, and alcalies; so that *Zwelfer* is not to be credited when he asserts the contrary. The distilled vinegar consists of water and acid. This acid is attracted into copper from the vinegar, whilst the water is rejected, and left by itself; and the acid

acid adheres almost unchanged to the copper, and unites therewith in the form of a solid body, but is again driven from it, little changed, by the force of the fire; leaving the copper only reduced to powder, and in other respects unaltered. And this can be done by no other body, that I know of, besides copper; because other metals, as gold, silver, mercury, and tin, do not admit this acid; but iron and lead do, tho' they change it at the same time; so that the acid cannot be obtained from them in a pure acetous form, but is a different thing: and hence it appears how great a difference there is in solution. The acid of vinegar is attracted into copper, and restored pure from it by distillation, without any considerable change, but only freed from its aqueous part: lead attracts the same acid, and rejects the water; but when endeavoured to be recovered by distillation, there is an oily fat liquor obtained in its stead, very different from the nature of vinegar: but if the acid liquor of vinegar dissolves iron, nothing besides water, here wonderfully changed, is recovered from it. Hence an acid united with other absorbents, or alcalies, whether fixed or volatile, is never recovered from them, as a pure acid again; so that perhaps only copper, or its verdigrease, can afford a fit body for strengthening the pure acid of vinegar.

PROCESS LIV.

The generation of tartar from wine.

WINES, especially those prepared from grapes, or of an acid and austere taste, usually afford a copious tartar, but not in perfection, till they are once thoroughly fermented: and they afford the purest when put up into a clean vessel. It is more plentifully obtained from the wine, when this has rested some time upon the lee, and in some measure gently consumed it. The tartar of fine white-wine is white, whence *Rbenish* wine affords the best, which is white and collected in thick pieces for medicinal use; and the whiter, heavier, more shining and thick the pieces, the better. That of red-wine is red, more impure, less firm, and the pieces less solid, and more unctuous: for more of this see the eighth process. This stony salt of wine is difficultly dissolved in water, or wine itself, but remains almost like a stone therein. If boiled in a large proportion of water, it dissolves in some measure, and makes a turbid liquor, wherein numerous shining corpuscles are observed to float; and thus in the boiling it constantly throws up a skin to the surface, which, if taken off with a skimmer, and put into a wide vessel to be dried, is called by the name of cream of tartar. And thus by degrees the whole quantity of tartar may be converted into a kind of white acid powder, excepting only a few feculent parts, remaining at the bottom.

If pure white tartar be boiled with twenty times its quantity, or more, of water, till the whole is perfectly dissolved therein, and the boiling liquor be now immediately poured into a cask, without admitting any feces, a crust will presently begin to form on all the internal parts of the vessel

The Practice of CHEMISTRY.

' touched by the liquor; and this crust continually increases, till, in a short
' time, nearly all the tartar shoots into little shining figured lumps, called
' crystals of tartar; which, being collected and gently dried, are thus to be
' preserved separate. The remaining water, when cold, retains but little
' of the tartar.'

These operations shew, that the nature of the salt which is produced by vinous fermentation, entirely differs in these properties from any other known salt. A new solution also of the cream, or crystals of tartar, may be made in fresh boiling water, so as to obtain them each time more pure and white; but the virtue of them both scarce appears greater for any chemical or medicinal uses, than that of tartar itself.

The use.

A knowledge of the eighth, and of the present process, greatly conduces to the understanding of the nature of fermentation, and the tartar produced thereby. And thus we procure this wonderful salt suited to so many uses. Dyers, silver-smiths, chemists, and physicians, require it on many occasions. The chemists prepare many things from it, and some of them capital ones. In medicine it is highly serviceable for gently cleansing the first passages, in a small dose, or for purging strongly in a larger quantity. And upon this subject that candid chemist *Angelus Sala* has wrote excellently.

PROCESS LV.

The resolution of tartar into water, an acid spirit, oil, and fixed alkaline salt, by distillation.

' **F**ILL two thirds of a glass retort, with choice pieces of the best white
' tartar, and place it in a sand furnace; apply a large glass receiver,
' or one that is of the greatest size, and lute the juncture with a common
' mixture of linseed meal. Apply a gentle fire for some considerable time,
' scarce exceeding a hundred degrees; there will come over a small quan-
' tity of a limpid, thin, tartish, somewhat spirituous, bitterish, and lightly
' odorous liquor, which is so penetrating, as easily to sweat thro' the luting.
' Let this be kept separate; then the fire being raised to the heat of
' boiling water, a white vapour comes over, and along with it a highly
' penetrating spirit, which is wonderfully flatulent, and will pass thro' almost
' any luting; and if we endeavour to confine it by that called the *lutum sa-*
' *pientia*, it bursts the glass by its elasticity; and it usually breaks out with
' force, or perspires at intervals, thro' the luting; and along with this wild
' flatulent spirit, there comes over a thin, and extremely subtil oil, of a
' yellow colour, a somewhat aromatic taste, bitter, heating, and of no un-
' grateful odour. This surprizing oil I have found so incredibly penetrat-
' ing, that when the neck of the retort entred five inches into the mouth
' of the receiver, and the juncture was closely luted, yet this volatile oil
' always

* always returned back, and passed thro' the body of the luting so as partly
 * to distil in drops, into a cup set underneath, and in part to run down the
 * external surface of the receiver: nor could I hitherto by any means pre-
 * vent this effect; for if a luting be applied, that the oil cannot pass thro',
 * the vessel flies to pieces. I did not therefore wonder to find *Paracelsus*
 * and *Helmont* so highly recommend this oil in diseases of the ligaments,
 * membranes, and tendons, which they upon experience have declared may
 * be cured by it, even tho' contracted.

* The former matters being collected separate, let the remainder be urged
 * gradually to the utmost degree of heat that sand will give, and thus
 * again a spirit will come over, and an oil, as before; but at the same time
 * a gross, black, fetid, ponderous, glutinous, and bitter oil, leaving the re-
 * maining tartar, black, sharp, and in every respect truly alkaline. If this
 * mass be urged with the strongest fire of suppression, it will still yield a
 * very thick, black, and pitchy oil, along with a certain smoke: and these
 * will continue to rise, how violent soever the fire be made, and how long
 * soever the operation is continued; and there will still remain an extremely
 * black, sharp, alkaline and dry mass, at the bottom; which being exposed
 * to the open air by breaking the glass, grows hot upon contact therewith,
 * and readily dissolves into a liquor: nor can it be kept dry, without great
 * caution; whereas the tartar, from whence it was produced, would scarce
 * dissolve in water.

* When this black dry mass is exposed to a naked fire, in the open air,
 * it takes flame, and after burning, leaves a copious white alkaline salt be-
 * hind, as strong, fiery, and pure, as can any way be prepared. It affords
 * but little earth, and readily dissolves of itself; if long detained in a strong
 * fire, it grows blue, of a marble colour, and sometimes brown; and thus
 * always becomes stronger, as we before observed in the twelfth process.

The use.

From hence we learn many particulars; and first, how wonderful a thing
 fermentation is, which separates all the gross parts, and leaves a transparent,
 subtile, fluid wine, which generates an almost stony body, that does not
 dissolve in cold water, whilst the principles of this body lay concealed in so
 thin a liquor. This stony mass also contains water, a spirit, and different
 kinds of oil, thick and copious. It is hard to conceive how this oil could
 lye concealed in the wine, which seems to contain alcohol indeed, but no
 such oil: but what is more surprizing, the entire mass of tartar is merely
 acid, and makes an effervescence with alcalies, as we shall clearly see in the
 seventy-fifth process; and yet by the bare action of no violent fire, in a close
 vessel, without any considerable separation of an acid, the greatest part of
 its whole bulk is changed from acid to true alcali: and this perhaps is the
 only example where a fixed alkaline salt is produced in a close vessel, by a
 moderate fire, without the free admission of the air; whilst in other cases,
 only a black insipid coal is thus produced: Who would have suspected
 that a manifest acid could, by this means, have changed to an alcali?

And

And if the acid water, the spirit, and the oil, be poured back upon this alkaline mass, from whence they were before extracted, and the distillation be performed as before, scarce any acid will come over, and little oil, but nearly the whole mass will be turned into alkali: whence we see that a large quantity of a very acid matter may be easily changed to an alkaline substance; but on the contrary, I am acquainted with no instance in chemistry, of such a manifest change of a strong alkali into an acid: whence I cannot sufficiently admire the particular nature of this tartar, as knowing nothing like it. The first distilled and highly penetrating oil of tartar is recommended for dissolving cold tumours, and for restoring motion to the dried tendinous parts in contracted limbs, together with the assistance of proper baths, fomentations and frictions. If these oils be rectified, and rendered more subtiler and penetrating, they are recommended by chemists, even for resolving gouty knots and concretions. It is said by many, that rich perfumes may be exalted by this oil; but they also say, that decayed musk and civet may have their scent invigorated, by being suspended in a jakes. Salt of tartar may be thus prepared in a greater proportion to the tartar employed, than by any other known method; and in greater plenty, the slower the distillation was performed. This also is the best, sharpest, most penetrating, and pure of all the fixed alkalies; nor is there any other known body in nature that affords more of such a saline alkaline matter, than tartar. And if the black alkaline matter, remaining after the most violent distillation, be set by in the retort slightly covered with paper, it wholly resolves into a liquor, which, being filtered, affords an admirable oil of tartar *per deliquium*, extremely fit for numerous chemical uses, and particular operations. If the same salt be first strongly calcined in an open fire, it thus also resolves in the air, and affords an oil of tartar *per deliquium*, but of a more sharp and alkaline nature than the former.

PROCESS LVI.

The tincture of gum-lac, by means of the twelfth, forty-seventh, forty-eighth, forty-ninth, and fifty-fifth processes.

THE chemists observe, that certain vegetables dissolve with difficulty in alcohol; yet being dissolved therein, sometimes afforded great medicinal virtues. Such medicines are dragon's-blood, gum-juniper, gum-lac, myrrh, &c. which are found of a very tenacious hardness, that will not easily admit a dissolution of their parts; which has therefore been attempted various ways, the most commodious whereof is the following.

Gum-lac is brought to us from *Asia*, and is a kind of rosin scraped up from trees by the ants, which build their nests of it, and thus collect it in great quantities in the island *Ceylon*, from whence the best is brought. Take of this pure gum, reduce it to fine powder, and moisten it with the alkaline oil of the twelfth, or fifty-fifth process, so as to make it into a soft paste, which being put into a round urinal glass, is to be set in our little

• little wooden furnace, with that degree of heat, as may gradually dry the
• mass. Then take out the urinal, and leave it in the open air without fire,
• where the alkaline oil will again resolve; after which it is to be dried a
• second time in the furnace, and thus by repeating the liquefaction, and the
• drying alternately, the glassy tenacity of the gum will be broke, and re-
• solved into a liquor of an elegant purple colour. Now let it again be
• gently dried, and carefully taken out of the glass, as being thus prepared
• for affording a tincture with alcohol.

• Put the matter into a tall chemical glass, and pour upon it pure alco-
• hol, enough to float three or four inches above it; stop the glass with
• paper, and set it in the same furnace, that it may simmer for two or
• three hours, which may be done without danger of losing the alcohol, and
• reason of the long and slender neck of the glass. Let the liquor cool, and
• pour off the clear tincture, by a gentle inclination of the vessel, into ano-
• ther glass, that is to be kept well stopped. The remainder may be treat-
• ed in the same manner with more alcohol, and the tincture poured to the
• former, till the matter by boiling will no longer tinge the alcohol; after
• which the matter may be thrown away as exhausted. The several tinc-
• tures being put together, and purified from their fæces, by standing, are
• to be distilled by a very gentle fire, in a glass body, till one half of the
• alcohol is come over, whereby being thickened, the remainder is to be
• kept for use, under the title of *Tincture of gum-lac*.

The use.

Hence we see that alkali, with the air and a digesting heat, opens a dense
body, so as to make it give out its virtue to alcohol; and the reciprocation
of drying by the fire, and moistening by the air, penetrates to the uttermost
parts, tho' there always remain some fixed part in these substances, incap-
able of being dissolved by the repetition of this action: whence the menstruum
extracts the more active virtue of such substances, leaving the grosser less
active matters behind. And hence we have an effectual, expeditious, com-
modious, and almost an universal method of preparing excellent tinctures;
the general virtues whereof depend upon the presiding spirit, secretly
lodged in these substances, and that often wonderfully contains their peculiar
virtues; again upon a rich balsamic part presiding in the same; and lastly,
upon a corroborating resinous part, which they generally hold; and these are
added to the virtue of the menstruum, or alcohol before examined. Hence
in general, all these tinctures may be pronounced heating and exciting to the
nerves and spirits, drying, preservative, strengthening, and constringent to
the vessels: but the present particular tincture of gum-lac is of great virtue
in curing the disorders of the gums, mouth, and teeth; in the scurvy, being
frequently used by rubbing it on the parts; and taken externally, it has the
same virtue, and safely cures that disorder, if not attended with too much
heat. It is also of great use in the goit, the rheumatism, and scurvy, from
a sluggish cause, as also in a *haemorrhagia*, dropsy, or the like. It may be
taken

The Practice of CHEMISTRY.

taken thrice a day in *Spanish* or *Canary* wine, after the stomach has been first cleansed and emptied. It has a grateful odour and bitterness, with an agreeable astringency, that shews its strengthening virtue, and is therefore highly commended in the cure of the *fluor albus*.

PROCESS LVII.

The tincture of myrrh, by means of the twelfth, forty-seventh, forty-eighth, forty-ninth, and fifty-fifth processes.

‘**P**ROCEED here in every respect as in the preceding process; by which means an extremely rich and useful tincture will be obtained for many purposes. This tincture has long been sought after by artists, who always complained, that this noble gum could not be held dissolved; and therefore attempted to dissolve it various ways, by different menstruums: but by the present method it succeeds excellently.’

The use.

We have here an example of chemical solution, chiefly for medicinal use. *Helmont* imagined, that if myrrh could find entrance into the innermost recesses of the body, it would have a great efficacy in the prolonging of life, so far as this might be expected from an uncorrupted state of the vital balsam. This tincture, by its detergent, embalming, or balsamic virtue, excellently heals any foul ulcers of the mouth, nostrils, gums, or other parts of the body, by their being touched or rubbed therewith. If the bodies of dead creatures be penetrated with this liquor, they having been first warmed, and then dried, it preserves them uncorrupted. Given internally, it is an admirable remedy in all languid cases, proceeding from a simple inactivity. It is principally serviceable in those female disorders which proceed from an aqueous, mucous, sluggish indisposition of the humours, and a relaxation of the solids; and therefore has extraordinary effects in the *fluor albus*, and all the diseases arising from the same cause.

PROCESS LVIII.

The tincture of amber by means of the twelfth, forty-seventh, forty-eighth, forty-ninth, and fifty-fifth processes.

‘**R**EDUCE the best transparent yellow amber to fine powder, in order to increase its surface; grind this powder in a glass mortar, with the alkaline oil made *per deliquium*, according to the twelfth and fifty-fifth processes; the longer the better, that it may become a thin, well-wrought paste; put it into an urinal glass, dry it in a warm furnace, and resolve it in the open air for several times, as in the two preceding processes; for it is hard

hard to be penetrated. At length the matter being well dried, put it into a tall bolt-head, with a very long and slender neck, pour pure alcohol thereon to the height of three inches above it, shake them together, and simmer them on the furnace for some hours, as may thus be commodiously done. The tincture will become red, and when cool, and grown clear by standing, should be carefully decanted from its faeces into a clean glass, kept close stopped. In other respects proceed as before, till almost the whole body of the amber be taken up in the tincture. This may also be prepared in the same manner by the means of alcohol alone, without alkali, tho' to better advantage with it.

The use.

Hence we see, that alkali has a power of gaining entrance for alcohol, into a body brittle like glass, whose wonderful, resinous, and particular nature no one has hitherto particularly explained; but in the composition thereof, a fossil acid, and a rock oil, or something like them, seem to concur; whence it is difficult to dissolve. Its tincture, however, is neither acid, alkaline, nor oily, but holds the whole substance of the amber dissolved. It is of a bitterish aromatic taste, wonderfully refreshing, having a perfectly restorative fragrance, and some degree of stipticity. When well made, it in the winter time grows thick, and deposits a kind of mealy, or somewhat resinous substance; which shews how richly impregnated it was with the dissolved amber: but when warm weather returns, it again grows clear, and takes up the powder it had let fall. If one half of the alcohol be drawn off from this tincture, the remaining thick part deposits a kind of powdered amber, which, being collected separate, is of a highly aromatic taste, and odour. It is very surprizing, that this substance should be so equally, and almost totally dissolved in alcohol, without any observable separation of its principles; yet at the same time acquire such noble medicinal virtues as were not before found in the entire amber; especially, as by distillation it is divided into such different parts, each of them of a different virtue and nature, as we shall see in the eighty-sixth process.

And hence again we see, by a manifest example, that chemical productions may differ incredibly, as they are obtained or prepared with a different menstruum, or in a different manner. And hence also we see how very different principles may lye concealed in a certain compound, without giving any sign of their being there, or of manifesting their own nature; and this, tho' the compound be very subtilly divided, either by trituration, or a menstruum. And hence again it appears, how much a simple division, made by a menstruum, without any extraction of the principles, may produce new virtues.

This tincture has an incredible efficacy in all those distempers, which proceed from too great a mobility of the immediate instrument of the human affections, spirits and nervous system; and particularly from a relaxation of the parts, thro' weakness. And hence it proves of wonderful service in hypochondriacal, hysterical, languid, cold, watery cases, and convulsions often proceeding from them. So that Mr. Boyle and Helmont have for this reason placed it among the noblest anti-spasmodics and anti-epileptics, when the dis-

order proceeds from those causes. And these three examples may suffice to shew the true methods of extracting tinctures from the hardest subjects. The dose and manner of using the present are the same as above delivered under the fifty-sixth process.

PROCESS LIX.

Tincture of benjamin, by the means of the forty-seventh, forty-eighth, and forty-ninth processes.

LET this rosin, which spontaneously flows from its tree in plenty, be ground to powder, and boiled in a glass-vessel with spirit of wine once rectified, without any farther preparation; and thus it resolves into a red and sweet-scented liquor, which being decanted clear, and more spirit poured to the remainder, and boiled therewith, nearly the whole body of the benjamin is thus dissolved, except a little shaggy matter. But if the alcohol were perfect, and boiled in this manner with the benjamin, the tincture becomes the richer: they are both of them odoriferous, and of a warm, bitterish, and balsamic taste.

The use.

Hence it appears, that an unctuous rosin may be perfectly and totally dissolved in alcohol, so as therewith to appear in the form of a considerably homogeneous and thin liquor; a little whereof being poured to a large proportion of water, the mixture immediately turns white, opaque, and milky, thence called virgin's milk; because if the face be washed therewith, it becomes rosy, and soft; and covered with a thin shining skin, if suffered to dry spontaneously. This mixture, therefore, is esteemed an innocent cosmetic; and when mixed with wash-balls renders them of an agreeable odour. This rosin of benjamin, and camphire, are wonderfully volatile, with a small degree of heat, and spontaneously dissolve in alcohol without alcali,

PROCESS LX.

Tincture of guaiacum, by means of the forty-seventh, forty-eighth, and forty-ninth processes.

PUT the refuse of fresh, green, and ponderous guaiacum-wood, reduced to small chips, or take the bark thereof in powder, and put it into a tall chemical glass; pour thereon rectified spirit of wine, so as to float four inches above it, without any other addition. Boil them together, in the manner above mentioned, for four hours, often shaking the glass; the liquor will thus become red, which is to be strained, after it is clarified by rest, thro' a linen strainer, to separate it from any impurities; then pouring fresh spirit upon the remains, boil them again, and preserve the

the several tinctures pure. The liquor, thus obtained, will be of a pungent, aromatic, acrid, hot taste, and odour: but if the alcohol employed were perfect, the tincture will always be the better.

If this tincture, prepared with pure alcohol, be distilled in a tall body, with a gentle fire, till only one fourth part be left behind, this will be a very rich tincture, fully impregnated with the virtue of the guaiacum. But if the spirit employed contained any water, the rosin would begin to fall, if the tincture was inspissated so high. But when pure alcohol is used, the tincture will easily bear to be thickened, and thus increase in virtue, without growing turbid.

The use.

We have here an example of an operation, whereby the oily, resinous, and balsamic part may be extracted from odorous woods, and preserved and employed for medicinal purposes. The liquor, also, thus obtained, afterwards serves to afford rosins. The virtues of these tinctures depend upon those peculiar to the wood, so far as they reside in the aromatic, balsamic, oily, or resinous part thereof. And thus these tinctures are prepared to excellent purpose, from *lignum aloes*, snake-wood, *Rhodium*, saunders, and the like; by the same means, and with the same menstruum. This tincture of guaiacum being externally applied, is a wonderful remedy in malignant venereal ulcers; whether in the skin, or fat, mouth, jaws, throat, &c.

PROCESS LXI.

Tincture of scammony, by means of the forty-seventh, forty-eighth, and forty-ninth processes.

THE milky, unctuous, thick juices, which spontaneously distil in plenty from wounded plants, usually appear resinous, when inspissated by the heat of the air, or sun: such juices are particularly those of the hawk-weeds, sow-thistles, goats-beard, succory, spurge, euphorbium, poppy, or the like; and these juices, when reduced to a dry form, and ground to powder, and boiled once or twice with spirit of wine, in the same manner as above, dissolve in great measure, leaving only a little earthy faeces behind: and this is particularly the case of scammony.

The use.

The tincture of scammony, so prepared, purges in a small dose, or in the quantity of two drachms, if mixed in three or four times its weight of the syrup of damask roses. These three last processes chiefly shew the action of pure spirit of wine upon vegetable compounds, according to this ancient chemical rule; that spirit dissolves its like. For alcohol, when perfectly pure, scarce extracts any thing more from well dried compounded vegetables, than the inflammable parts, spirit, balsam, oil, colophony, rosin and resinous gum, and what is merely saponaceous; leaving a pure dry salt and earth behind.

behind. If, therefore, the artist knows that all the particular virtue required resides in these parts, then the operation must be performed with pure alcohol alone, as we directed in guaiacum; but when the virtue required lies in a mixture of the oily, resinous, saline, and saponaceous parts together; it is better to use the common rectified spirit than alcohol; because that spirit acts, by its aqueous part, upon what is saline and saponaceous, and by its alcohol, upon what is balsamic, oily, and resinous; so that by this means the united virtues may be obtained in the tincture. This is evident in the roots of hellebore, hermodactils, jalap, mechoacan, and turbith; because the tinctures drawn from them with a spirit only once rectified, purge much better than those extracted by pure alcohol. For if a resinous tincture be drawn by alcohol from jalap, it purges less; whilst the remainder being boiled in water, communicates a purging virtue thereto. But if the tincture be extracted with common spirit, it proves highly purgative; and the remains contain scarce any thing worth the extracting. Hence we learn, that a fixed alkaline salt is not required in the making of many tinctures, because it would either destroy, or change their particular virtues; and that they are not always to be made with alcohol: but we are first to consider what spirit should be used. All the tinctures, prepared with pure alcohol, will burn entirely away, almost like pure alcohol itself; whence it is manifest, that this menstruum extracts only the inflammable part from the compound, and leaves the rest behind. If, therefore, the virtue of a plant entirely resides in the saline saponaceous part, to boil it with water is better than alcohol. The opium dissolved in water is the best, the next is that dissolved in wine, and the next in spirit of wine; but always the worse, the better the spirit.

PROCESS LXII.

A purging potion from the sixty-first, and a sudorific potion from the sixtieth process.

IF two drachms of the tincture of scammony, prepared as above, with rectified spirit of wine, be mixed with thrice its weight of a proper purging syrup, as that of rhubarb, for example, and this dose be taken upon an empty stomach, in a distemper, constitution, and age, that requires so strong a purge, it commonly has the desired operation in purging the bile. If the like tincture, prepared with common spirit from jalap, be, in the quantity of half an ounce, mixed with an equal weight of the syrup of buckthorn, a potion will thus be obtained, which, without occasioning much disorder, plentifully purges water: whence we are furnished with an excellent hydragogue in those distempers that require it. And therefore this tincture is kept ready at hand, to be mixed up occasionally for pharmaceutical use. But when the tincture of guaiacum, prepared with pure alcohol, and inspissated to a half, is mixed with four times of the syrup of the five opening roots, and taken upon an empty stomach in the morning,

- ‘ morning, lying in bed, it presently distributes itself over the whole body,
- ‘ which it thus warms, and promotes a copious sweat; and hence it is com-
- ‘ mended in the venereal disease, when seated under the skin.’

The use.

Many virtues of vegetables usually reside in their rosins, which are generally tough, and apt, by their tenacity, to stick to one part of the body, and thus their virtues are either retarded or hindered; but when dissolved in a spirituous, vegetable menstrum, they operate quicker, and in a much less dose: rosins dissolved in spirits are so sharp, that they cannot be drank alone; and if diluted with water to render them potable, they are presently precipitated into a tenacious mass: whence nothing seems more proper than to mix them with a thick syrup, where they cannot be precipitated, but are mitigated by the saccharine part, which by its extraordinary simplicity does not at the same time change, or impair their virtue.

PROCESS LXIII.

Virgin's milk, from the twenty-ninth process.

- ‘ **T**HE red tincture of benjamin, prepared according to the fifty-ninth
- ‘ process, appears transparent, even when viewed with a microscope;
- ‘ but if a single drop of water be added to it, it presently turns white,
- ‘ opaque, and appears dreggy to the naked eye; and if the whole tincture
- ‘ be mixed with ten times its quantity of water, it grows perfectly milky,
- ‘ thick, and curdled, and throws out nearly all the benjamin, in the form of
- ‘ a fine powder, and precipitates it to the bottom of the vessel; so as that
- ‘ little of the former taste and odour remains behind.’

The use.

This experiment shews the nature of rosins with respect to alcohol, and to water, as also the nature of a white precipitation of an oily matter in water; (a) the production of a resinous body by an extraction with spirit; and the manifest separation of the same, from the spirit, by water. And this resinous substance, precipitated by water, appears like fine, thin, polished skins, which, if laid on the skin of the body, render it uniform, soft and somewhat shining; whence this tincture is used for the curing of pimples, little ulcers, freckles, and breakings out of the skin.

(a) See process 15, 16, 17, 21, 26, 27, 28, 29.

PROCESS LXIV.

Rosins, from the sixtieth and sixty-first processes.

LET the tinctures prepared with alcohol, from fat resinous vegetables, according to the sixtieth and sixty-first processes, be first well clarified by standing, then distilled in a glass-body with a gentle fire, till only one fourth remains behind: the alcohol thus drawn off is to be kept for the same use again. Then pour the thickened tincture into a low glass, with the mouth wide enough to admit the hand; and let this vessel contain twelve times the quantity of fair water, in proportion to the thickened tincture. The mixture thus will instantly grow thick, white, and soon exhibit yellow curds, which, fallen to the bottom, constitute a gross, viscous, unctuous, and somewhat transparent matter; then set the glass in a sand surface, and draw off the remaining alcohol by means of a still-head; continuing the operation so long as the veins in the head shew any spirit to rise, and add this spirit to the former. At the bottom there will remain the water, with the above-mentioned matter below it. This matter liquifies in hot weather, but grows hard in the cold. The water being thrown away, tho' it still retains some odour or taste, tho' but little virtue; let the resinous matter collect and unite into a mass at the bottom; it will first be flexible, soft, and, when touched, stick incommodiously to the fingers; but when washed for some time in several waters it begins to cool and harden, and, when dried, appears a hard, brittle, transparent body, that will run with heat, dissolve in oil, and alcohol, but not in water, and burn in the fire like oil. This matter is called by the chemists rosin; and requires to be kept in a cool dry place, and in a close dry vessel.

This rosin may be thus prepared from almost any oily, ponderous, dry, and resinous parts of vegetables. Nature often produces the like from vegetables, but no where more perfect than in the camphire-tree, which yields a pure, white, transparent, highly odorous, volatile rosin, tho' hard to grind; and next to this is benjamin, which is also a pure volatile rosin, copiously afforded by the tree. But when pure alcohol acts upon resinous plants, whilst yet green and juicy, the water abounding in these juices mixes with the alcohol, and dilutes it; whence it acts like common rectified spirit, or rectified spirit of wine, in proportion as the plant contained more or less water; and thus its action becomes different.

The use.

This experiment, which is considerably general, shews the nature of rosin, which in the plant seems to be a pure thin oil, according to the observations made under the thirty-fourth and thirty-fifth processes, concerning the origin of inspissated oils. And hence chemists are taught under what various physical forms oils may subsist, in respect of heat and cold; for the rosin, which

which in a certain degree of cold is hard and brittle, soon resolves by heat into a pure fluid oil. Some have supposed that rosins are generated, whenever any strong acid is mixed with a clear oil; upon observing that the strong and fiery spirits of nitre and vitriol turn with oils into a pitchy mass, which, when farther perfected by the fire, becomes a true rosin: and therefore that the sulphur thus produced is a true rosin of the earth. But there is room to doubt whether the coagulation of the oil proceeds from the acid; because by the natural conversion of balsams into rosins the acid is always more separated from the balsam, the more the balsam, which was first liquid, grows thick and hard; and at last there is less acid found in the rosin, than in the more fluid mass: and even the rosins which are thus said to be produced by a mixture of acid and oil, yet always differ from those prepared by nature, or by the means of alcohol. These rosins soon dissolve in alcohol, but sulphur never.

The rosins, thus prepared, manifest their oily nature by being totally inflammable, and seem to contain their former presiding spirit: for the smell, taste, and particular virtue of the subject is always found in the rosin, tho' this is to be understood only so far as it remained in the oily part of the plant. And hence these virtues are long detained, and preserved for years, in the viscous substance of the rosin; whereas they would be otherwise soon lost in the plant itself. And hence it often happens that the rosins, taken into the body, pass thro' it undivided, by reason of their tenacity, and without having their spirits extricated to perform their proper actions; as not meeting with the bile, or other saponaceous fluid, to dissolve and open them: and this is frequently regretted by physicians, whilst they direct these rosins in form of pills, which may pass the body without being dissolved, and without producing the desired effect. These rosins also generally have a manifest, sharp, caustic, inflammatory, violent virtue; so that if they stick to the tongue, or the jaws, they prove very troublesome by their acrimony; and this effect they often have upon the stomach and intestines, and thus they may prove mischievous, by stimulating and inflaming. And thus the rosins of coloquintida, euphorbium, hellebore, jalap, scammony, &c. sometimes occasion violent and dangerous purgings, that cannot easily be stopped. In order to prevent both these ill effects, it has been found proper to grind them in a cold glass mortar, for a considerable time, with an equal quantity of dry sugar; so as thus to prepare a fine powder, which being afterwards mixed and taken in any syrup, never passes the stomach undissolved, nor sticks in the folds of the intestines, but proves an excellent and expeditious kind of purge. So likewise, if mixed with a little yolk of egg, this will dissolve their tenacity, and promote and increase their efficacy: and when thus treated, these rosins also will prove purgative, which are obtained from simples not purgative themselves, as we see in the rosin of guaiacum.

Some of the greatest artists have observed, that the proper distilled aromatic oils, abounding with their own spirits, grow resinous, as often as they are deprived thereof. And this is certainly found in some oils; for if pure oil of cinnamon be dissolved in alcohol, and the alcohol be with a gentle fire drawn over from it by distillation, it carries over the spirit with it, and leaves

leaves the oil behind deprived thereof, and resinous. But as the purging virtues of certain plants partly reside in that resinous matter, which alcohol extracts, and partly in another active part of the plant, which dissolves in water, as appears in jalap; the remainder of such a plant, after the pure alcohol has extracted all the rosin, will afford another part by being boiled in water. And if this decoction be strained, inspissated with a gentle fire to an extract, and afterwards exactly mixed along with the rosin dissolved in the yolk of egg, there will thus be obtained an excellent composition, containing almost the whole medicinal virtue in a little compass.

PROCESS LXV.

Essential extracts, shewn in saffron; by means of the forty-seventh process.

NATURE has prepared, in certain particular parts of certain vegetables, a determined kind of body, so different from all others as scarce to be referred to any other known kind; and has at the same time endowed it with virtues, otherwise inimitable. We have an example of this in the chives of saffron, which the principal chemists have esteemed so much, as to call it the philosopher's spice, and to denote it by the initial letters *aroph*, which stand for *aroma philosophorum*. It is incredible how rich this saffron is in colour, taste, odour, and virtue; how small the bulk is that possesses all these rich faculties; and how tender and easily corruptible the thing itself is; and therefore requires a peculiar method of operation.

Take, therefore, two ounces of the choicest fresh *English* saffron, dried, and either cut small or remaining whole; put it into a clean bolt-head with a long and slender neck, pour upon it so much of the purest alcohol, containing no foreign thing, as may float four or six inches above it: then stop the glass slightly with a wreath of paper, put it into our wooden little furnace supplied with a live coal buried under sifted ashes, that the heat may be only a hundred degrees. Leave it thus in digestion for three days, the vessel being often shook; let it afterwards rest, for twenty-four hours, in a cold quiet place; then carefully strain off all the tinged liquor thro' a piece of clean linen, placed in a funnel set in a clean glass; and keep it closely stopped. It will be of a bright red colour, the saffron, remaining at the bottom of the glass, will be found paler than before. To this pour the like quantity of fresh alcohol, and proceed as before, and mix the tincture thus acquired with the former; the saffron will now remain paler. If more alcohol be added to it, and the process be repeated, a still poorer tincture will be obtained, which ought to be kept separate: the saffron will now become pale, but otherwise will have the same appearance, and bulk, as before. To this if water be added, digested therewith, and poured off, it will be of a yellow colour; put on fresh, and continue thus till no more tincture can be extracted; and now the chives will appear quite white; and, if gently dried, will retain their former figure, tho'

tho' they appeared much shrunk, perfectly inodorous, and insipid, so as scarce to be distinguished from bits of clean thread; whence it is wonderful, where the seat of that surprizing matter extracted from it should be, which is found to give so rich a tincture to so large a proportion of alcohol. Let the tincture, procured by the two first digestions, be distilled in a glass body, fitted with its head, and perfectly well-closed, with a fire of a hundred degrees, till about an ounce remains behind, which, when cold, is to be poured into a glass vessel, to be kept carefully stopped. It will prove of an exceeding red colour, a highly fragrant odour, and a bitter, aromatic, penetrating taste, and have the consistence of thin oil. Let it be kept under the title of the essential extract of saffron. The spirit that came over in the distillation will be limpid, and colourless, but retain the grateful and aromatic smell and taste of saffron. This is to be reserved for the same use; and thus every time becomes the richer.

The use.

This surprizing experiment shews us a new species of matter, which we can neither call oil, spirit, gum, rosin, resinous gum, wax, or balsam; but it is something perfectly singular, and of a spirituous oily nature. This extract mixes with water, spirit, and oil, and has such exhilarating virtues, that being used too freely, it occasions an almost perpetual and indecent laughing; but used moderately, it becomes properly exhilarating; it tinges the urine red, and is particularly said to destroy the petrifying power thereof in the kidneys, and therefore to be an extraordinary remedy against the stone. It is the true *aroph* of *Paracelsus*. There is no occasion previously to digest the saffron with bread in the heat of horse-dung, in order to procure its tincture, which is thus rendered rather worse than better; for in our present preparation, all that is efficacious is brought together without loss, or impairing its peculiar virtues, or any sensible change. And these preparations being miscible with any liquor, and of a very penetrating subtile nature, easily enter the finest vessels of the body, and, by their extraordinary mobility, diffuse their virtue thro' the whole, and chiefly excite the animal spirits. Lastly, they have that admirable virtue, which the author of nature has planted in them, and which can never be explained upon any principle, and can only be known in itself from its effects.

The like extracts may be obtained from ambergrease, musk, civet, balm of *Gilead*, liquid amber, liquid storax, cloves, mace, nutmeg, angelica, galengal, orrice, and other barks and flowers of a subtile fragrance; whence it is plain that these spirits of particular bodies may be extracted and collected by alcohol; and hence their sudden action seems to proceed, because the most spirituous alcohol, uniting with these active spirits, makes a medicine that immediately diffuses its virtue every way, and carries it thro' the body. And when a similar remedy is prepared from several such ingredients mixed together, it easily appears, that thus an admirable remedy may be compounded, rich in united virtues, according to the intention of the artist; so that nothing of this kind can be invented more effectual. These extracts are best taken in canary, or the like rich unctuous *Spanish* wine.

PROCESS LXVI.

Essential extracts of camphire, by means of the forty-eighth and forty-ninth processes.

THE extraordinary nature of this substance, tho' several times considered, again requires to be examined by this experiment. Camphire is obtained from its own tree, in the hottest countries, being lodged in the wood, particularly in the bark, in its own natural crystalline form. That is the best, and most valuable, which comes from *Borneo* and *Ceylon*. There is another sort obtained by distilling the wood, bark, and the root of the camphire-tree, or the cinnamon-tree of *Ceylon*, which has the smell of camphire; for these parts, being infused, digested, and distilled with water, afford a limpid, penetrating oil, rich in the taste and smell of camphire; and a certain part of this oil, concreting in the cold, turns to camphire, which being sublimed in a clean vessel with a gentle fire, is thus purified. It is clear like crystal, hard to grind, extremely odorous, and totally and spontaneously volatile. It dissolves perfectly in alcohol, and therewith makes a pellucid, and highly odorous liquor. Being distilled along with alcohol, it either wholly rises therewith, or becomes volatile soon after, and comes over in a homogeneous liquor. As soon as the least drop of this clear liquor is put into water, the whole body of the camphire is instantly separated therein, and recovered; whence it appears, that this particular substance resembles rosin, tho' it is volatile; in which respect it differs from all other rosins. It dissolves in spirit of nitre, spirit of vitriol, and *aqua fortis*, as it does in alcohol; but upon the addition of water recovers its own nature and substance, unchanged: but this is not found in any rosin besides; whence it appears, that there is a great difference in those called true vegetable rosins. This liquor also may, by gentle distillation, be thickened at pleasure, and when so thickened, appears like an oil.

The use.

This operation shews the nature of camphire already explained. The spirit prepared from it by distillation is highly penetrating and volatile; it is drying, preservative, embalming, good against gangrenes, promotes perspiration, and, with respect to the blood and serum, proves a styptic: but I judge it is less proper, when applied to the naked nerves, because it dries too much.

PROCESS

PROCESS LXVII.

Chemical quintessences, by means of the processes from the twenty-third to the thirtieth, as also the forty-eighth, and the forty-ninth.

PUT any distilled aromatic, or essential oil, into a clean and dry glass, and pour to it twelve times its quantity of pure alcohol, distilled from alkali, so as to contain not the least water. Shake them together, and the oil will disappear, and intimately mix with the alcohol, so as to form one simple and transparent liquor; but no water must be contained in the oil, otherwise the experiment will fail.

Alcohol, therefore, and essential oil are of such a nature as intimately to mix and unite together, provided they be both perfectly freed from water; for if only the glass were moist, or the breath interposed, it would hinder the effect; and, when the solution is perfect, and the two liquors are thoroughly mixed together, the addition of water turns them white and opaque, whilst the water unites with the alcohol, and separates the oil.

If the alcohol, saturated with the oil, be carefully distilled, in a close vessel, with a gentle fire, and several times cohobated, the oil will thus gradually be made so volatile, as in great measure to rise along with the alcohol: whence oils are rendered more moveable, and more subtile, and are exalted to the highest degree of penetrability, like that of spirit, tho' still retaining their native virtues. But if, with a fire of only ninety degrees, a mixture of alcohol and these oils be distilled, the alcohol will rise by itself, or only carry with it the presiding spirit from the oil, leaving the oily part behind: and, if with great care and caution, the thinner part be several times separated from the thicker, by repeated gentle cohobations, the alcohol will at length be so impregnated with these spirits, as to appear almost pure spirit itself, leaving a gross exhausted oil behind.

The use.

The ancient chemists conceived that fire, air, water, and earth, contributed to the composition of bodies, with the addition of a fifth thing, which, made of the four common elements, enriched the whole, by its own particular and inseparable virtue, whereon the colour, odour, taste, and virtue of each body principally depends: and therefore they supposed, that each particular thing, consisting of four essences, had a fifth essence added to it, which was extremely small in quantity, yet of very powerful efficacy, so that, when separated and added to another substance, it animated the spirits thereof: upon which subject *Isaac Hollandus* and *Paracelsus* deserve to be read. There is scarce any known method more proper than the present for preparing quintessences. Thus if a single drop of quintessence, so made, with oil of cinnamon, be mixed and drank with a glass of *Spanish* wine, it

instantly gives a grateful briskness to the flagging spirits, and therefore proves an admirable remedy in faintings, suffocation, and want of spirits: nor do we know, that the art of chemistry can go farther in obtaining the virtues of vegetables. If a drop of such a mixture of alcohol and oil be let fall into water, it presently turns milky, which shews when oils are adulterated with alcohol: and hence also we understand the power of alcohol, which principally acts upon the spirits and oils of plants, by mixing and fixing them intimately with itself; and thus making a compound, which afterwards seems to act with an uniform virtue. And tho' these oils exist under very different forms in vegetables, yet they may still be united with alcohol, provided there be no water in either: and we find that the native spirit always adheres to this oily matter, under whatever form it appears. All these preparations have a great affinity with fire, for such quintessences, being taken, heat the body; and if the quantity be large, scorch and burn it; when externally applied, they produce all the effects of a sharp inflammation, even up to a gangrene itself: but enough of this for the present.

PROCESS LXVIII.

Dry quintessences, by means of the sixty-fifth, and sixty-seventh processes.

TAKE alcohol, wherein an aromatic oil is dissolved, pour it upon ten times its weight of dry loaf sugar, reduced to fine powder; grind them together exactly for a long time, in a glass mortar, that they may unite; put the mixture into a china vessel, set in a glass body, kept on all sides moderately warm, that thus the remaining spirit, which moistens the matter, may gently exhale, and by means of a still-head, be collected in the form of a liquid quintessence. And thus the sugar will remain dry in the china vessel, yet impregnated with the quintessence. Let it now immediately be put up into a glass vessel close stopped, and preserved under the title of a dry quintessence. By taking a drachm of the finest wheat flower, five drachms of loaf-sugar, and grinding them dry in a glass mortar, then adding a drachm of the liquid quintessence, and proceeding as before, an elegant dry quintessence will be obtained.

By taking a drachm of the liquid quintessence, made according to the sixty-seventh process, and half a drachm of the essential extract, according to the sixty-fifth, and three drachms of fine sugar, and as much fine wheat flower, and proceeding as before, nearly the same kind of preparation will be obtained, but more compounded.

And as any of these kinds of oil may be dissolved in alcohol, and so brought into an uniform liquor, tho' consisting of various sorts, and thus employed to the same uses; it appears that these noble compositions may be made by various mixtures at the discretion of the artist: and hence there are infinite ways of varying these forms, each whereof may, for excellence, vie with the rest.

The use.

Here we see to what a length chemistry may reach in affording forms of medicines of great efficacy, in little compass: for if a scruple of our dry quintessence be mixed with an ounce of *Spanish* wine, we have hence a little draught containing the utmost virtue that can be obtained from aromatics. If therefore a prudent physician shall justly know the necessity and use of such a remedy, he may hence derive it from chemistry, for his purpose. These preparations have this convenience, that they may long be preserved perfect for use, and may be safely and commodiously carried in voyages, journeys, and in camps, where furnished shops are not at hand: and here again we have the bounds of chemical perfection.

PROCESS LXIX.

The simple aromatic spirit of lavender-flowers.

TAKE six ounces of fresh and ripe lavender-flowers, gathered in a warm clear afternoon, and twelve pounds of common spirit of wine, and distil by the rules of art, in the alembic and worm, till the liquor begins to come over milky. What arises first is a limpid spirit impregnated with the taste and odour of the plant, and must be kept separate. A thick white liquor will now begin to follow, a pint whereof is to be collected, and kept apart: there will remain behind a brownish black liquor, together with the flowers, but not much of the manifest virtue thereof; the first liquor is called the spirit, and the second the water of lavender.

Take three ounces of the like flowers, and pour the former spirit and water upon them, and distil as before. Keep the pure limpid spirit separate, under the title of the double spirit of lavender; but draw off none of the white water for fear of burning. A quart of fresh water may however be poured into the still, and then a pint drawn over, which will serve in other the like distillations. In the same manner, two ounces of recent flowers may be distilled with the preceding double spirit, and the water be afterwards obtained; by which means the spirit will be so much the richer in the native spirit of the lavender. Water is here added, lest the flowers, added after the first distillation, should become dry, and burn, whilst the last spirit was running off. And by repeating the distillation with fresh flowers every time, the spirit thus becomes excellent. The same operation may be performed, tho' flower, in a glass body or retort, with little trouble, and without foulness; and thus I have often carried these spirits to the highest perfection. And this operation is universal, for obtaining all the spirits from odoriferous, aromatical flowers; the principal whereof are garden cloves, saffron, jasmín, lavender, lilies, marum, orange-flowers, rosemary-flowers, &c. but a principal spirit of this kind is that of rosemary, every where celebrated, and too much used under the name of *Hungary* water.

The

The use.

It is easy to perceive that the essential oil of the flowers is here raised in the distillation, as in the twenty-fifth process, and along with this oil the spirit of wine rises almost pure, like alcohol, according to the forty-eighth process; and therefore this spirit dissolves the spirit of the lavender, and the oil that rises with it, according to the sixty-seventh process. But after the alcohol is drawn off, and the water begins to follow, then the ascending oil turns the water milky; whence is easily understood how these spirits are procured by art, and exalted at the pleasure of the artist.

And hence we may understand the virtue of these spirits, as approaching very nearly to the liquid quintessences of the sixty-seventh process, so that we need not here add any thing more about them. The agreement appears plain, because these spirits, when well prepared, turn milky with water.

PROCESS LXX.

The simple aromatic spirit, from the dry leaves of mint.

TAKE the leaves of mint fresh dried, and rubbing them a little between the hands, put them into a still, and add thereto twenty times their weight of common spirit: draw off one half by the worm, and keep what comes over under the title of spirit of mint. Express all the juice from what remains in the still, and take half of the former quantity of the leaves of mint, and pour the former spirit, and all the expressed liquor thereon; now again distil to a half, and repeat the operation to a third time, reserving what comes over under the title of the treble spirit of mint.

And thus these spirits may be produced from all the like plants. This spirit of mint is incomparable in vomitings, unattended with inflammation, and for wind and gripings in the stomach and intestines, proceeding from an acid, mucous, cold, or watery cause; for in these cases, half an ounce gives immediate relief.

PROCESS LXXI.

The simple aromatic spirit from the green leaves of rosemary.

THE leaves also of the richest aromatics, tho' less juicy, when fresh, will excellently afford the same spirits. Thus, for example, take of rosemary leaves, gathered from the tops of the sprigs, and therewith half fill a glass retort; pour spirit of wine thereon, till the retort be two thirds filled; then distil in our little wooden furnace into a large receiver, as long as the spirit appears to run in veins, which ceasing, it is time to leave off.

off. Let the water, with the rosemary, remaining at the bottom be kept apart; then clean the retort, and put in fresh leaves, pour on the former spirit, and the water squeezed out from the former rosemary; distil again, and repeat the operation to the third time, by which means an excellent spirit will be obtained. I formerly in this manner repeated the operation a great number of times, in expectation of at length obtaining an extremely perfect spirit of rosemary, but was mistaken in my purpose; for after so many cohobations, the spirit had a very ungrateful odour, like that of wax new gathered.

Hence it appears, that the same spirit resides in the flowers, leaves, and even the tender twigs of certain plants, and may thence be extracted; for this spirit cannot be distinguished from that prepared from the flowers of rosemary in the sixty-ninth process, and has the same virtues. The flowers of lavender, thyme, wild-thyme, sage, origanum, calamint, and all the sharp aromatics, are fit for this operation. And hence also it appears, that the same aromatic spirits may be obtained excellent from the dry barks, woods, roots, and seeds, as well as the green; as we see by the noble spirit, which may thus be drawn from yellow saunders.

PROCESS LXXII.

A compound aromatic spirit.

IT has sufficiently appeared, that the presiding spirit is a particle wherein a particular virtue resides, that has often an incredible power; and that this spirit is lodged in essential oils: again, that these oils may, along with their spirits, be mixed among one another into an uniform fluid, in which all these spirits are united together; and lastly, that this mixture may be dissolved in alcohol, so as to make a liquor extremely rich in medicinal virtues, or a certain compound, aromatic, oily spirit. It easily appears, that there is no one certain limited method for preparing these spirits, provided only such simples are chose, as agree in smell and taste, whose virtues will answer the trouble of the composition. The following process therefore will serve as an example, rather than a rule; being what I have often used for the making of a *sal volatile oleosum*.

Take of fresh *Sevil* orange-peel, cinnamon, citron-peel, *China* orange-peel, and lemon, of each four ounces; the flowers of orange, citron, lemon, lavender, red roses, and rosemary, of each two ounces; the roots of angelica and florentine orrice, each an ounce; cloves, mace, and nutmeg, each two drachms; rectified spirit of wine fifteen pounds; distil according to art, in a common alembic, so long as the spirit comes over limpid, and let this be kept separate, as likewise the next two or three pints of white liquor, under the title of aromatic, spirituous compound-water. When the operation is intended to be repeated, take all the above-mentioned simples, and the spirit of wine as before, and add to them all the water here prepared; by which means, the spirit obtained will be the more

more excellent : and thus procuring and reserving the same water each time, and using it seasonably, I have always obtained noble spirits, as may be easily imagined ; for at length they were pure like oil. When the spirit, thus prepared, is again to be drawn over from a few of the same fresh simples in a glass body, suspend in the still-head a little ambergrease, first well ground, and included in a piece of linen ; and thus the ascending spirit will subtilly dissolve its fragrant part, and mix therewith.

The use.

By considering what is delivered under the sixty-ninth, seventieth, and seventy-first process, it will easily appear to what purpose these spirits may serve, and how far their virtue may properly reach ; for they can never, by any known art, be converted into the spirits of the body, but always remain of their own foreign nature, whatever chemists may say to the contrary : and therefore they can never supply the defect of animal spirits. Consequently, it is impossible that the admission of these into a body worn out with age, should supply the office of the vital spirits ; they however, by their wonderful agility, grateful fragrance, agreeable taste, and a certain inexplicable affinity with the animal spirits, wonderfully contribute to excite them of a sudden, but for no long time, and by their too powerful actions they will oppress and destroy the native virtues of our spirits. And hence, when internally used, tho' they raise the spirits for the present, they commonly leave the body much more languid, and always in a state that requires to be further stimulated by the same means. And thus I conceive that I have sufficiently explained their true uses, according to the rules of genuine chemistry and medicine.

PROCESS LXXIII.

Soap from express'd oils and fixed alcali, by means of the thirteenth process.

TAKE a quantity of express'd oil-olive in one glass, and an equal weight of oil of tartar in another, pour the oil gently upon the lixivium, and it will float thereon, and the two liquors remain perfectly distinct. Shake the vessel wherein they are both contained, and the mixture will immediately appear white, opaque, thick, and somewhat viscous ; and, when suffered to stand in this state, it will continue for some time equally mixed, but at length the oil and the lixivium will separate from each other ; whence it appears, that express'd oils, by means of the acid always lodged therein, are disposed to mix with alcalies, even tho' diluted with water ; but that this union is so weak, as easily to be separated. Again, it seems probable, that the acid is the means of procuring this combination ; because oils, deprived of their acid, more difficultly unite with alcalies. If this mixture be gently boiled over a slow fire, till the water is gradually exhaled, it comes into one consistent white mass, of a nauseous oily smell, and a sharp, alkaline, ungrateful, unctuous taste ; and will easily dissolve in the air : but if in the boiling, a just proportion of the dissolved alcali or oil be added, or mixed therewith, so as that the compound may perfectly

perfectly dissolve in water, without separating from its oil, and yet manifest nothing alkaline to the taste, and remain long in the air without running, it is then called perfect soap. It was afterwards found, by a successive repetition of experiments, that the stronger the alkali, the more perfect the soap; and as it was observed, according to our thirteenth process, that quicklime wonderfully increases the power and fiery nature of alkali; an alkali, prepared by means of the same, began to be used instead of the simple kind, for the making of soap; and because they also observed, that the union was made more perfect by long continued boiling, and that this boiling required a larger proportion of water, they added water more plentifully, and at length, by repeated trial, they likewise found that a certain proportion of oil and alkali was required; and thus by successive degrees, the certain and determinate way of making soap was found.

They take the fixed, alkaline, fiery salt, prepared with quicklime, according to the thirteenth process; this they dissolve in such a proportion of hot water, that the lie may support a new-laid egg; and this the soap-makers call their capital lie. They afterwards dilute a part of it with more water, till a fresh egg will sink therein; and this they call their weaker lie. They afterwards mix their oil-olive with an equal weight of this weaker lie, by stirring them well together, till the whole becomes white, then boil the mixture with a gentle fire, keeping it continually stirring, till the water being exhaled, the remainder begins to unite; at which time they throw in thrice the weight of capital lie, in proportion to the oil, and mix and boil till the mass becomes so thick, that a little of it, laid upon a cold stone, appears to be of a due solid consistence; and if now a part of this cold mass is dissolved in water, it manifests no signs of oil. This shews that the oil is well united with the alkali; but if any oil still appears, the addition of a little more capital lie is required; and the boiling must then uniformly be continued till the soap will perfectly dissolve in water: at this time the soap is tasted, and if it proves sharp and alkaline, it is a sign that alkali abounds too much therein. And therefore a little more oil is added, and the boiling continued, till at length a mass is obtained, so hard as to cut in the cold, and that will perfectly dissolve in water, and neither taste alkaline upon the tongue, nor run spontaneously in the air; and thus the soap is perfected.

Instead of oil-olive, any other fat substance may be used, as the fats of animals, and the oils of fish; thus black soap is made from train-oil, or the boiled blubber of whales: but the purer the alkali is, and the more scentless, tasteless, and less ungrateful the oil, the better the soap, especially for medicinal use.

The use.

Here we see an intimate combination of native oil with fixed alkali, by means of water and fire, into a homogeneous mass, which will perfectly dissolve in water; whence it appears, that the oil here loses its former fat nature, and acquires another more agreeable to water; and that this is brought about by the means of sharp, fixed alkali. And therefore where the hu-

humours of the body abound with oil, salts are generally useful; and consequently in this case a prudent use of fixed alkaline salt may be allowed. And hence also we are shewn a way, whereby the acrimony of alkali may be entirely blunted, so as to grow soft, and put off its corrosive nature, viz. by the means of oils. Whence again, in such cases where the like sharp, saline matter predominates, fresh express'd oils, drank in plenty, will blunt it; and this has been often practised with good success in the acutest diseases, and the more pernicious kind of scurvy; and, again, when this acrimony is spontaneously generated in a certain place, as in the kidneys or bladder, where the stone, drinking in the urine, turns it to this kind of acrimony: but in the soap so produced, tho' the tenacity of the oil is abolished, yet the former virtue of the lixivial salt remains, whereby it deterges, without danger of corroding; for when mixed with water, it makes a strong saponaceous lie, which by heat, motion, and trituration, dissolves gums, oils, rosins, and gross fats, rendering them also saponaceous, or soluble in water; and thus it has a scouring, detergent, opening, cleansing property. And hence it renders coagulated humours fluid, opens old obstructions, and thereby restores the lost use of the parts. It also has great effects upon concretions, consisting of gross earth and oil; it prevents acids from coagulating the chyle or milk, and even resolves them after coagulation. Whence it appears to be almost an universal opener, diluter, resolver, and thinner in the body, in the above-mentioned cases; being drank upon an empty stomach, well diluted, and at different times, in a sufficiently large quantity, and assisted by the motion of the body. It is likewise wonderfully serviceable, being externally applied in sinuous and fistulous ulcers. It may be tinged and disguised, by giving it a grateful colour with saffron, turmeric, cochineal, or other pigments; and if it still proves disagreeable, on account of the nauseous smell acquired by the oil in boiling, it may be corrected by a little balsam *Peru*. But its use is highly pernicious in those distempers where life is in danger from a putrefaction, that dissolves and corrupts the humours, as has frequently appeared in the plague and other putrid distempers, according to the just observations of *Diemerbroeck*. Many other particulars of chemical and medicinal use may be easily deduced, concerning this noble production, from what is above delivered. Soap affects what neither water nor oil could perform, does that with safety that alkalies do with danger, and can perform what other salts cannot.

PROCESS LXXIV.

Soap, from distilled oil and fixed alkali; by means of the twelfth process.

CHEMISTS, considering the virtues, which by experiment they found in distilled oils, were concerned to find, that these oils, not mixing with water, could not enter and act upon the humours of the body; and therefore observing that express'd oils might be successfully united with fixed alkali, they went upon trying the same with distilled oils, but found that these lost their virtue by boiling, and even could not thus be joined with the alkali; and hence

hence tried various experiments to unite these different bodies, till excited by the directions and promises of *Helmont*, some of them seemed to have found the means of effecting the thing. I my self formerly made many tedious experiments to this purpose, and at length succeeded, as I shall now relate. The secret consists in this, that the alkali should be perfectly sharp, pure, and dry, and come in contact with an oil perfectly deprived of water: all the rest is successfully performed by the atmosphere; but if the least water should enter, the experiment will be frustrated.

Take the purest and strongest fixed alkali, prepared according to the twelfth process, in the fifth paragraph, and grind it in a clean iron mortar with an iron pestle to fine powder, the finer the better, whilst it still remains thorowly hot from the fire, and almost ignited; then put it into an extremely dry, and well heated urinal, and set it in a hot and dry place, on a clear and dry day; and at the very instant that the hot salt is all collected at the bottom of the glass, let fall therein the true ætherial and pure oil of turpentine, so that one drop may immediately follow another, and fall upon the middle of the hot salt; the oil itself having being first well heated; and thus the oil will immediately, with a great fume and a hissing noise, be attracted into the thirsty salt, and diffuse itself intimately thro' the whole mass. Continue to pour in the oil quick, till enough is entered into the salt, and floats above it, so as to prevent it from touching the external air, which is always moist with water, or from touching the surface of the salt. Set the glass in a cellar, where being covered with paper, the oil will soon disappear, and be united with the alkaline salt; then pour some more of the warm oil thereon, and mix it with a stick into the former mass. Set the whole by, as before, and continue thus, till nearly thrice the quantity of the oil is united with the salt; the whole will be now a saponaceous and penetrating mass, which, the more it is stirred, the sooner and better it is made; whence it may be expeditiously obtained, by putting it into a strong glass, and suffering it to be carried daily, and shook in a stage coach, as *Doctor Grew* and *Bohn* have formerly observed. The experiment has always succeeded well, when I have observed the foregoing circumstances; but never, if the least of them were neglected. The operation is known to be well performed, if a little of the soap will mix with water, without manifesting any sign of oil. If the soap, thus prepared, be long kept in the urinal, there usually rises, by degrees, along the sides of the glass, a certain white crystalline salt, of no disagreeable odour, and of a penetrating, mild, saline, but not alkaline taste; which is wonderfully insinuating, easily soluble, and affords an highly useful, medicated soap.

And this salt, which is but little in quantity, I suspect gave origin to the assertion, which perhaps is too free, that fixed salt of tartar was here rendered volatile by means of oil added thereto, so as to become a substitute for the alcahest; but when I urged this soap with fire, after it was well prepared, I did not find the promised volatile salt.

The use.

This experiment also shews us the thirsty nature of pure fixed alkali,

whereby it drinks in, and unites these salts with itself; and again, how a sharp fiery alkali may be softened into a mild oily salt. We have sufficiently spoke to the virtue it has against acid, austere, and viscous coagulations, under the former process; we must however observe that all the virtues there related are here found more noble and active, and constantly somewhat heating. And hence we understand the nature of distilled oils with regard to fixed alcalies, or of fixed alcalies with regard to them; and of the new production by a proper combination of the two. *George Starkey*, and his followers, call this soap volatile; but I could never find it so, as I said above. This is the soap which *Matthew*, an empirick of *London*, made under the title of *Matthew's corrector*, wherewith he mixed opium, and the roots of hellebore and liquorice, and then digesting them together, he made general pills thereof, that were diaphoretic, scarce emetic, or purgative, but anodyne, tho' they would often vomit the next day. *Starkey* published a more correct preparation of these pills at the end of his *Pyrotechny*, where he boasts of their virtue after the manner of chemists, unjustly pretending that the virtue of the hellebore remained entire, tho' deprived of its vomiting quality. And so much for the making of soap. The excellent *Mr. Homberg* observes that a strong lixivium hereof, mixed with a sharp acid, is strangely muddied and changed; whilst the alkali being attracted by the acid, lets go the oil. These soaps being well dried and digested with pure alcohol, are in some measure resolved into the lesser elixir of the philosophers, where the sulphur and spirit are united.

P R O C E S S LXXV.

The preparation of tartarised tartar.

REDUCE the purest white tartar to fine powder, and boil a sufficient quantity thereof with ten times its weight of water, in a large copper vessel, till the tartar appears sufficiently dissolved; let the vessel remain over the fire, that the water and the tartar may continue constantly boiling; the liquor, being now tasted, proves acid, and is almost transparent, and tolerably pure. Then let fall from an height a quantity of oil of tartar, drop by drop, into the boiling liquor, which is still to be kept boiling, whilst the oil of tartar is dropped in. Upon the falling of each drop, there arises a great ebullition in the liquor, proceeding from the meeting of the acid and the alkali, as appears from hence, that the ebullition soon after spontaneously ceases, and is raised again by dropping in more of the alkaline liquor; and because this is performed in a strong boiling heat, large spherical bubbles are generated on the surface of the boiling liquor, that presently crack, burst, and appear again. In these bubbles chemists have found, or rather imagined they found, the figure of grapes. The operation is thus to be patiently continued, till at length no more effervescence arises from dropping the alkaline liquor into the boiling lixivium. And now the acidity of the tartar will be so saturated with such a quantity of its own alkali, as neither to appear acid, nor alkaline, but

but a third new salt. But this point of saturation must be exactly hit, otherwise the salt will be acid if too little alkali were added, or alkaline, if too much; great caution must therefore be used at the end. This liquor is to be strained hot and quick thro' flannel, till it becomes clear; it will be of a blackish brown colour, of a particular bitterish, saline, unctuous taste, but scentless; if inspissated by heat, till a skin appears on its surface, and then set for some time in a cold place, it deposits to the bottom and sides of the vessel, certain saline grains, which when collected, are a tartar easily soluble in water, even in the cold; whereas before it could scarce be dissolved therein, without a boiling heat: whence this preparation may properly be called soluble tartar.

The use.

Tartar comes so near to a stony hardness, as to remain insoluble in its own wine, which is thus contained, as it were, in an earthen vessel; whence the Germans appositely call it *wine-stone*. It has a manifest acidity; by the prevailing force thereof it acts kindly upon the first passages; and this acidity is the cause that it makes so strong an effervescence with its own fixed alkali, which is so easily produced from it, as we saw in the fifty-fifth process. For, after this acidity is overcome by the alkali, the tartar becomes easily soluble, and a new kind of salt, which has a considerable virtue in the body, when taken upon an empty stomach, dissolved in water: for thus it deterges, and gently purges, and helps to cure many inveterate diseases. Externally used, it cleanses foul ulcers, and disposes them to heal: but whether this be the boasted remedy of *Paracelsus*, by means whereof he declares he cured all fresh wounds, in a few hours, without suppuration, I cannot tell. That medicine he called *Jameck*, which seems derived from the German word, which signifies to conglutinate. Thus much I can say, that a solution of this salt in water, is one of the best menstruums hitherto known in chemistry; as any one may learn by boiling gum-lac, myrrh, and the like therein. Whence he will find it can scarce sufficiently be commended; and hence it is plain, that used as a medicine, it will dissolve viscous matters in the first passages; and it is even supposed to dissolve the tartarous matter of the human stone, generated in the receptacles and passages of the bile and urine, provided it be used plentifully, every day, the dose being gradually increased. It is useful in the stone, jaundice, and hypochondriacal disorders. Lastly, the examination of this process shews, how proper cream of tartar is in all those distempers, where the bile in particular, and other humours putrefy in the intestines, from a burning fever, or other causes, and thus become alkaline; for this disposition is then corrected by the latent acidity of the tartar, and at the same time converted, in the body, into a mild aperitive and soluble salt, which opens the passages without greatly stimulating them, and clears away obstructions.

PROCESS

PROCESS LXXVI.

Regenerated tartar.

TO a quantity of sharp, pure, and dried fixed alcali, contained in a large glass, with a narrow neck, pour strong distilled vinegar, till it almost covers the salt; scarce any sensible effervescence will appear, which seems strange, because so strong an alcali might be expected to make an effervescence with the acid; but it seems, on the other hand, as if so weak an acid would not make an ebullition with so strong an alcali: shake them strongly together, and then some small, short-lived ebullition appears. Pour on more distilled vinegar, and then a greater ebullition will arise, and appear sufficiently manifest; after shaking the glass, add a third quantity, and then a violent ebullition, frothing, and hissing, will be found, and prove the stronger, the more the glass was shook; and this continues a long while, so that the vinegar poured on makes the stronger effervescence, the nearer the operation approaches to the point of saturation with the alcali; which point is generally obtained, when about fourteen times the weight of strong distilled vinegar is added to the alcali. Now, towards the end, let the mixture be well heated, and long and strongly stirred, that no more acid may be poured on, than is exactly required to obtain the point of saturation; which will at length be hit, by continuing to add a little of the distilled vinegar by degrees, and well agitating the mixture, till the addition, and shaking in of a little more, no longer causes an effervescence, even in the heat. Then let the mixture stand warm, for twenty-four hours; and if upon shaking, it makes no ebullition, again drop in a little vinegar, and shake the vessel, and if now no effervescence arises, then the exact point of saturation is hit. During the experiment, the violent effervescence throws off a very elastic vapour, which bursts out of the glass with a hissing noise, after having been confined by pressing the hand against the mouth of the glass, whilst it was shook, and then suddenly taking it away: and if the orifice should be closely and strongly shut up, during the effervescence, the glass would be burst to pieces. The liquor, thus prepared, is transparent, of a particular odour, not acid, and of a taste neither acid nor alkaline, but particularly saline, and almost without acrimony. It has a mild and innocent virtue, tho' powerfully attenuating and resolving; being purgative, diuretic, and sudorific; whence it proves an admirable remedy in chronical diseases, attended with a tenacious matter, being given in a proper dose, at proper seasons.

The liquor being decanted clear from its faeces, and distilled in a glass alembic, affords a pure simple water; whilst the liquor remaining behind becomes of a brown or blackish colour, and at length perfectly black, fat, thick, of an extremely penetrating, or as it were melting taste, which discovers it to be of a saponaceous, penetrating, and resolving virtue. Take a little of this liquor, and mix it with a little vinegar; when if it yields an effervescence, this shews that the alcali still predominates, and therefore

The Practice of CHEMISTRY.

itself, especially since it flows like wax at the fire. It seems certainly to be the *acetum radicum* of the ancient chemists, as in its preparation vinegar returns, and is joined with its own matrix of calcined tartar; but whoever shall over carefully endeavour to dissolve, purify, filter, inspissate, or calcine this salt, in order to make it white, he will find it fly off into the air, and be lost, and may thus indeed be convinced of its volatility, with the loss of his labour and cost. And this admonition I give, chiefly because *Senertus* recommends a scrupulous diligence in purifying this salt; which is not only a loss, but an impoverishing labour.

PROCESS LXXVII.

Tincture of tartarised tartar.

REDUCE dry tartarised tartar, prepared according to the seventy-fifth process, to fine powder; put it into a tall bolt-head, and pour pure alcohol thereon, till it rises four inches above it. Stop the glass with paper, and boil gently in our little wooden furnace for twenty-four hours, by which means the alcohol will become of a gold colour, and of an aromatic, hot, penetrating taste. If the operation be repeated with fresh alcohol, a white salt will remain at the bottom. Let the tinctures be inspissated by a gentle fire, till a tenth part remains condensed behind.

The use.

This process serves to shew that part in the salt which dissolves in alcohol. The tincture thus prepared is aromatic, heating, cleanses ulcers, and heals up wounds: the remaining salt is purer, and more simple than before; which shews, that salts may be whitened, by drawing a tincture from them with alcohol.

PROCESS LXXVIII.

The dissolution of regenerated tartar in alcohol.

PUT regenerated tartar, prepared as above, and made as dry as it can be with safety, into a tall bolt-head; pour thereto six times its quantity of pure alcohol, and boil them carefully with a gentle fire, in our little wooden furnace; they will thus be united into an uniform compound liquor, that deposits some fæces at the bottom, which being subsided, let the liquor be poured off pure. And if any salt remain undissolved behind, add fresh alcohol, and proceed as before. Lastly, distil the liquors with a gentle fire to one half; and thus the tincture or solution of regenerated tartar will be obtained.

The use.

We have here the alkali, the oily acid, and the oily spirit of vegetable subjects united together, whereby the most active principles of plants are freed

freed from their indolent earth, and yet remain safe, or not dangerous, on account of their acrimony; and this mixture also seems to be the lesser elixir of the philosophers; which the ancient chemists commended for restoring health. Certainly it dissolves almost all obstructions, penetrates the vessels, agreeably stimulates the vital faculties, and cures by sweat. It is also a most excellent solvent in chemistry, whereby bodies are dissolved into their smallest and most active parts, without impairing their seminal virtue; so as to gain them entrance into the innermost recesses of the body, in order for conquering the most obstinate distempers. It is no less serviceable when externally used in wounds, tumours, and ulcers. And that the poor may not want so excellent a remedy, it may be directly prepared by mixing potashes, with fifteen times their weight of strong vinegar, then straining and inspissating the solution; and thus, without loss of labour, or great expence, a medicine may be easily prepared for use. And this medicine was known to the ancient Romans, and is mentioned by Pliny in his preface, where he says, *the ashes of vine-twigs, being dissolved in vinegar, is drank in diseases of the spleen.*

PROCESS LXXIX

Harvey's tincture of salt of tartar.

TAKE the black alkaline salt, remaining in the retort after the strongest distillation of tartar, according to the fifty-fifth process; reduce it to powder, in a hot iron mortar, with a hot pestle, and immediately put it into a tall bolt-head; pour the best common spirit thereon, so as to rise four inches above it; boil with a gentle fire in our little wooden furnace, for twenty hours; and thus a black, thin, bitter, aromatic, lixivious liquor will be obtained, which, being decanted pure, may long be preserved perfect in a close glass for use, under the title of *Harvey's tincture of salt of tartar.*

The use.

The common spirit, consisting of water, acid, and alcohol united, coming to boil with the alcali of tartar, that still remains oily, makes a mild and safe lixivium; the alcali being here tempered by the acid, oil, and alcohol: whence we have a noble kind of medicine and menstruum; wherein if vegetables be boiled or digested, it dissolves them to good advantage. In chirurgery, it is an excellent remedy for cleansing, deterging, drying, and healing all weeping, purulent, putrid, sanious and virulent ulcers, as well the fistulous as the sinuous and burrowing; and also for taking down proud-flesh, especially if artificially mixed with a little oil. It has similar effects when used internally, in distempers where acid, austere, aqueous, mucous, or terrestrial matters, and coagulations abound, provided they be not attended with a putrid dissolution of the humours; and hence it is commended in old obstructions of the *viscera*, collections of water, dropical dispositions, the green-sickness, jaundice, and cold gout. It acts strongly as a diuretic, a

diaphoretic, and sometimes as a purgative; and may be safely given in a large dose. Two or three drachms thereof being mollified with an ounce of the syrup of the five opening roots, and diluted with fennel-water, will have a very good effect; being taken in the morning fasting, and repeated three or four times at due intervals, or a better than most other remedies. Hence the famous Doctor *Harvey* deservedly recommends it; tho' the ancient physicians also were not unacquainted with the like for the same purposes, as may appear from *Dioscorides* (a).

PROCESS LXXX.

Helmont's tincture of salt of tartar.

TAKE the black salt of tartar remaining upon the distillation of tartar, put it into a large and strong crucible, burn and calcine it well in the fire, with care to prevent the coals, or other matters falling into it, till it becomes white, and all its oily matter be consumed: Or, to make more dispatch, take a parcel of the best tartar, and tie it up in cap-paper, first made a little moist, then put it into the fire, and surround it every where with live coals, and let the fire at last go out of itself; then removing the hot ashes, an alkaline saline mass will be found run together at the bottom: this is called common salt of tartar. Let either of these preparations be dissolved in water, filtered and exhaled away in a clean iron pot, after the Manner described in our twelfth process, and let the salt be afterwards calcined in the same manner, as is there described, and be reduced to fine powder, which the finer it is, the fitter it will be for the purpose: this will be excellent salt of tartar. Then have ready at hand a tall and dry chemical glass, with a wide mouth, one third full of pure and warm alcohol; let also the whole neck of the glass be well heated all round, lest it should burst by the heat of the salt of tartar, to be now presently poured in; fit a paper funnel to the mouth of the glass, and thro' this pour the powder of the salt of tartar now extremely hot, as it comes from the fire, and therefore dry, into the alcohol. If all these particulars are rightly observed, the salt will fall into the alcohol with a great hissing and noise, and immediately cause an ebullition. When a sufficient quantity of salt is put in, stop the glass slightly with a cork, and when all is cold, pour in more alcohol, till the glass be three fourths full; shake them together, so that no salt may hang on the sides of the neck of the glass, but all of it remain entirely under the alcohol, otherwise these adhering particles of salt would dissolve by the moisture of the air; then mix themselves with the alcohol, and frustrate the whole laborious operation. Let the glass now be set in a heat of a hundred degrees, and be kept often shook, and lightly stopped to exclude the moisture of the air, which is here so prejudicial. The liquor will thus soon become of a deep and beautiful red colour, and contain the manifest virtue of the alkaline salt,

(a) See *Dioscorides* book I. p. 186.

as appears by the smell and taste, tho' scarce by any effervescence, but especially if it be very cautiously inspissated by distillation: for being afterwards examined, it is found manifestly saponaceous, and somewhat saline. If the least particle of water be mixed with either ingredient, no tincture will be obtained, but the alcohol remain colourless, and transparent upon the alcali, how long soever they stand together. And thus even the lightest sign of moisture will also appear; whence I do not wonder to find, that some eminent chemical authors have wrote, that this tincture was impossible; for it cannot be made if any one, even of the slightest circumstances here required, be omitted. And as to what other professors of the art have wrote, that the colour, by our method communicated to the alcohol, should be owing to a spontaneous change thereof in time; this is confuted by the experiment itself, and the marks above described; but it is easy to mistake in so laborious and difficult an experiment. I have not found the tincture alcaline, but rather of a compound, saponaceous nature.

The use.

This experiment again shews, that pure fixed alcali has an appetite of attracting almost all liquids to itself, whenever it exists by itself. Thus it greedily drinks in water, acids, and oils, as appears by the processes above performed; and in our present process it drinks in alcohol also, tho' not so strongly, or so closely, as the former. And hence we have a new method of making an extremely subtil soap of alcali and alcohol; for this tincture is truly saponaceous, as appears by rubbing it between the fingers, where it has a manifest, detergent property, in a high degree; whilst pure alcohol, thus treated, would manifest itself only by driness. It shews itself to be saline and fiery by its taste; it does not, indeed, make a manifest effervescence with acids, or readily precipitate bodies dissolved therein. If the pure tincture be inspissated by distillation, it leaves a saline, saponaceous, scarcely alcaline, but sharp, coagulated substance at the bottom, of a deep red, or almost black colour. As a menstruum, it incomparably dissolves all distilled oils with great expedition and perfection; it likewise extracts excellent tinctures from gum-lac, myrrh, and amber: it is recommended by the chemists for internal use, against distempers arising from a stubborn tartarous matter: but to say the truth, it cannot be given, unless diluted with water, wine, or the like mild liquor, otherwise, it instantly burns the parts it touches; and when weakened, as it requires, to what purpose was all the pains taken to purify the alcohol, and unite it with the alcali? I judge, therefore, that the preceding process affords a more excellent medicine, with much less trouble. The present operation, however, is by no means useless; for it teaches many particulars, some whereof are mentioned above, and others we now proceed to mention.

I have long considered upon that casual saying of the great *Helmont*, that if spirit of wine be distilled from thoroughly calcined salt of tartar, one half of it will be turned to water. This I understood of spirit only once rectified; especially, because in another place, he says, the same thing happens with vinegar, as was above observed under the forty-ninth process. But because

the principal followers of *Helmont* declare, that we are to understand this saying of pure alcohol, one half whereof is joined to salt of tartar, whilst the other is turned to water; and therefore that true alcohol consists of these two separable parts; and also that the salt of tartar is thus likewise converted into that noble balsam, or *jamech*, of *Paracelsus*, which miraculously heals wounds without any inconvenience; I judge proper here to declare what I have myself found with great labour. I made a perfect tincture of the salt of tartar, in the manner above described; it was extremely strong, red and fragrant, and of a sharp, fiery, and almost alkaline taste; I digested it upon its alkali for many months, then set it by for four years; the salt continued extremely dry at the bottom, and the tincture exceeding red above it: I then poured out all this salt, and the tincture, into a perfectly dry, and clean glass body; they were extremely fragrant: I distilled off all the alcohol with a gentle fire, having exactly luted the junctures; the alcohol was perfectly limpid, subtle, and fragrant; the salt at the bottom was now of a purple colour, tho' it was white before; I poured the alcohol upon its salt, and distilled as before; the alcohol now rose with more difficulty, and a saline red mass remained behind; the alcohol was of a fiery taste; I thus continued to cohobate it for one and twenty times, after which, a black saline mass remained at the bottom, and the alcohol came over exceeding sharp; in the last place I urged this black, alkaline, strong smelling mass with the greatest heat, that sand would give, upon which there came over, not alcohol, but water, tho' I had with the utmost care prevented any water from getting in. And thus I found that water might be obtained from this salt and alcohol, but not half the quantity in respect of the alcohol; and still I have some doubt whether this water did not proceed from the air, or was not secretly taken up upon returning, and distilling the alcohol so many times over: this I am certain of, that the alcohol thus first put to digest with the salt of tartar, for so many months, and afterwards left for some years therewith, then drawn off from it two and twenty times, did not make this salt volatile, but left it fixed and perfectly black. Having now broke the vessel, and taken out all the salt, I exposed it, in a hollow glass, in a cellar, where it run into a brown liquor of a sharp alkaline taste, which I reserved by itself. This labour I undertook, that I might at length be certain of the nature of salt of tartar, and of the conversion of alcohol into water by its means; the union of alcohol with salt of tartar, by distilling it therefrom; and the volatilizing of salt of tartar by means of alcohol: and hence we see what the great promises made about these matters end in. The alcohol, so many times cohobated, was extremely clear, fragrant, of a fiery taste, would burn away without leaving any faeces, and made no kind of effervescence upon the addition of acids: and this was the reward of my labour.

PROCESS

PROCESS LXXXI.

Elixir proprietatis with distilled vinegar.

TAKE choice aloes, saffron and myrrh, of each half an ounce, cut and bruise them, put them into a tall bolt-head, pour twenty times their own weight of the strongest distilled vinegar thereon, let them simmer together in our little wooden furnace for twelve hours: now suffer the whole to rest, that the fæces may subside, and gently strain off the pure liquor thro' a thin linen. Put half the quantity of distilled vinegar to the remainder, boil and proceed as before, and throw away the fæces. Mix the two tinctures together, and distil with a gentle fire till the whole is thickened to a third; keep the vinegar that comes over for the same use; and what remains behind is the *elixir proprietatis*, made with distilled vinegar.

The use.

Thus we obtain an acid, aromatic medicine, of great use in the practice of physic; for when externally applied, it cleanses and heals putrid, sinuous, and fistulous old ulcers, defends the parts from putrefaction, and preserves them by a true embalming virtue: it also heals ulcers, and cures gangrenes in the lips, tongue, palate, and jaws. It has the same effects in the first passages, when used internally, as often as putrefied matter, corrupted bile, concremented phlegm, worms, and numberless distempers proceeding from these four causes, are lodged or seated therein. Again, it has nearly the same effects in the blood and *viscera*, as may easily appear from knowing the virtues of the three ingredients, when dissolved in a subtle vinegar. It is to be taken in a morning upon an empty stomach, at least twelve hours after eating: it is given from a drachm to two or three for a dose, in sweet wine, mead, or the like; walking after it, or having the belly gently rubbed. If taken in a larger dose, and with a somewhat cooler regimen, it always purges; if in a less dose, and often repeated, it cleanses the blood by secreting thick urine; and generally performs both these operations successively. But, if taken plentifully, while the patient is in bed, and the body well covered, it acts as an excellent sudorific; and afterwards usually purges, and proves diuretic, and thus becomes every way useful: whence I conceive that this is the best acid *elixir proprietatis*, good in numerous cases, and at the same time safe. *Paracelsus* declared, that an elixir made of aloes, saffron, and myrrh, would prove a vivifying and preserving balsam, able to continue health and long life to the utmost possible limits; and hence he calls it by a lofty title the elixir of propriety to man; but concealed the preparation, in which *Helmont* asserts the alcahest is required. *Crollius* formerly used the oil of sulphur made by the bell, as a menstruum in this case, upon considering, according to the doctrine of *Paracelsus*, that an hungry acid was proper in stomachic remedies; but when this is used, the aloes and myrrh are scorched; and acquire a stony hardness, so as not afterwards readily to dissolve.

The Practice of CHEMISTRY.

dissolve in alcohol: for this use they require that the strong acid of the sulphur should be diluted. Hence I conjectured, that a mild, oily, vegetable acid would prove a commodious and proper solvent in this case for medicinal uses; and upon adding an equal quantity of alcohol to the elixir prepared in this manner, it becomes more balsamic, mild, and effectual. It in every respect resembles the *Pilule Rusi*, and may be successfully used in their stead.

PROCESS LXXXII.

Elixir proprietatis with a distilled water.

REDUCE equal quantities of aloes, saffron, and myrrh, to powder; put it into a tall chemical glass, add twenty times their weight of distilled scurvy-grass water, and proceed as in the preceding process.

The use.

This elixir, tho' excellent, has this inconvenience, that when long kept, it grows mouldy; but it has extraordinary virtues in the body, like those described in the last process, excepting that it wants the acid. It is an excellent purge, and instead of scurvy-grass water, any other aromatic water may be employed.

PROCESS LXXXIII.

Elixir proprietatis with fixed alkali.

TAKE the same ingredients as above, put them into a bolt-head, and pour as much oil of tartar *per deliquium* to them, as will make them into a moderately thin paste, which is to be digested in our little wooden furnace, with the heat of a hundred degrees: the longer the digestion is continued, the better, the vessel being stopped; and thus in time the alkali will intimately dissolve the aloes and myrrh for this purpose. When the matter is thus prepared, let it be treated with any distilled aromatic water, as described in the preceding process; and thus there will be obtained an alcalized *elixir proprietatis*, with a distilled water. Or else, to the species, prepared as above, add twenty times their weight of pure alcohol, and boil them for twelve hours after our manner; when cold, carefully pour off the upper liquor from the faeces; add more alcohol to the remains, and proceed as before, till all the virtue be drawn out; then thicken the tinctures together by gentle distillation, till the liquor acquires the consistence of oil of almonds; and keep it under the title of *elixir proprietatis* with alkali and alcohol: the virtues of which preparation cannot be sufficiently recommended; or if instead of alcohol, common spirit be used, a thicker,

thicker, and no less noble elixir will be obtained. In this preparation, I have sometimes used instead of alcohol or spirit, the simple or compounded spirit distilled from aromatics, as in the sixty-ninth, seventieth, seventy-first, and seventy-second processes; and the elixir, so prepared, has proved excellent, especially when made with the compound spirit of the seventy-second process.

The use.

These elixirs are of frequent and excellent use in all distempers proceeding from austere, aqueous, cold, phlegmy, and scirrhus causes, or uninflam-matory obstructions; they purge nearly by all the emunctories of the body, and are at the same time grateful to the nerves and spirits. They excel-lently forward the birth, promote the menses, bring down milk, kill worms, and supply the defect of the bile; whence practitioners cannot be without them. They act by means of the alcali, the dissolved ingredients, the spi-rit, and the waters employed, in various ways.

PROCESS LXXXIV.

Elixir proprietatis with tartarised tartar.

TO the same ingredients, reduced to powder, pour thrice their weight of the liquor of tartarised tartar, made according to the seventy-seventh process; digest them in a close vessel for three days, in a heat of a hundred and fifty degrees; and thus the ingredients will be entirely dissolved into an uniform pappy mass, much better than by vinegar, water, or alkaline liquor. Then pour on twenty times the quantity of alcohol, in respect of the ingredients, and boil them gently for twelve hours: let all cool and stand at rest, then decant the clean liquor, and treat the rest with more alcohol, as before, till nearly the whole be dissolved: for little faeces will here be left. Inspissate all the elixirs together, with a gentle fire, to the thickness of oil; preserve the alcohol for the same use; and thus will be obtained the *elixir proprietatis* with tartarised tartar and alcohol.

The use.

This elixir being prepared with a compound, and wonderfully opening salt, has greater virtues than the foregoing; so that it is admirable in old inveterate obstructions, which it powerfully resolves, without offending by any acid or alkaline property: for these compound salts, along with what they dissolve, generally pass quick thro' the vessels of the body.

PROCESS LXXXV.

Elixir proprietatis with regenerated tartar.

PUT the above-mentioned ingredients into a tall glass, and pour thereto thrice their weight of the liquor of regenerated tartar; digest for three days, and the aloes and myrrh will be thus almost entirely dissolved, and the saffron thoroughly open'd; then add twenty times the weight of pure alcohol, with respect to the powder, boil them gently for twelve hours, and in other respects proceed as before; there will remain a few faeces, which may be thrown away. Inspissate the elixir to an half; reserve the alcohol for the like use; the elixir will be and always continue thick and turbid.

The use.

In this last process the ingredients are almost wholly dissolved, so as to become uniform and potable; whence I have found this elixir to have an incomparable opening, and dissolving virtue in most chronical diseases, where it mightily liquifies the concretions in the vessels, agreeably stimulates the nervous system, so as to throw off the matters thus dissolved, and prevents putrefaction, which in these cases is so frequent and destructive. Hence it relieves the *viscera*, restores their actions impaired by an obstructing matter, resolves the tumours, and thus cures numerous distempers, scarce otherwise curable: whence I have been almost inclined to esteem this elixir as the elixir of *Paracelsus* and *Helmont*.

In all these processes we have an example of the chemical solution and preparation of the same thing, by various solvents; and learn by what means these solutions have different virtues, according to the difference of the menstruum; and that these elixirs ought to be prepared with different menstrooms for daily use, according to the intention of the physician. So likewise they act differently, according as they are determined by the prescriber. Thus, if taken with *Venice* treacle, they prove sudorific; if along with a cathartic, they purge; and if along with whey, or mineral waters, they prove diuretic, provided the patient walk abroad in the cool air. They all of them preserve the bodies of animals from putrefaction, if suspended therein, except that prepared with water; they are all of them excellent in case of carious bones, except those prepared with acids; and hence they should always be ready at hand for practice, as being almost general medicines: and no wonder, since saffron is a true exciter of the animal spirits; aloes an excellent and innocent purgative; and myrrh the highest preservative: but in those distempers where the blood is too much broke, in large bleedings, or the hemorrhoids, or where the humours are in too violent a motion, they are by no means proper, but hurtful.

PROCESS LXXXVI.

The analysis of foot.

TAKE of the blackest and driest foot, gathered in the chimney of an oven where nothing but bread is baked, and gathered on a very fair day; with this fill a large glass retort almost to the neck; apply a large glass receiver, after the neck of the retort has been thoroughly cleansed on the inside, and lute the juncture with the common linseed paste; raise a fire of a hundred and fifty degrees, and keep it up equably: a large quantity of transparent water will thus come over, with considerable violence; so that if the fire was immediately made strong at first, the receiver would easily crack. Continue in this manner, so long as any clear water comes over, which it will long do, altho' the foot was dry. Then taking away this first water, and pouring it into a glass, apply the receiver again, and raise the fire a little above two hundred degrees; a white, milky, fat water will now come over in quantity, and with considerable violence; proceed with a slowly increased fire, so long as this continues; keep it apart, apply the receiver again, and raise the fire briskly; a yellow, volatile, copious salt will come over, and stick all round the sides of the receiver; continue the fire thus brisk, so long as any salt rises; then with the strongest heat, that sand will give, and with the heat of suppression, there rises a thick black oil. Let all cool, and there will be found, in the neck of the retort, a salt which could rise no higher, even by so violent a fire; but in the bottom of the retort there remains a black feculent matter, the upper surface whereof is covered with a very thick, whitish, saline crust, which both in colour, figure, concretion and *striae*, resembles the common sal-ammoniac. If the milky water be rectified, it affords a very penetrating volatile spirit, and some sharp volatile oily salt.

The use.

This process was absolutely necessary, because all the foregoing only exhibited those parts of vegetables, which, being treated by various preparations, and different degrees of fire, either remained fixed, or were transmitted from one vessel into another. But here we are taught what the agitation of an open fire can move, change, expel, and drive thro' the air by burning, first in the form of smoke, then of flame, lastly of exhalation, and how high it may carry them. For a chimney is a kind of still-head, converging in an open top, and sometimes rises to the height of above thirty feet, and carries foot up to the top, and after this discharges a black smoke, at its upper orifice, and disperses it thro' the air, where it seems gradually to vanish. It may deserve to be considered, what an immense quantity of such matter is, by the force of fire, thrown up from the surface of the whole habitable globe, in the places where fire is constantly used; whence we may learn, that combustible vegetables, their smoke, flame, and foot, and the black clouds dispersed in the air, consist of one and the same matter, agitated

by fire. This matter consists of several parts, viz. (1.) A fetid, oily, bitter, unpleasant, nauseous spirit, residing in the water, that first comes over, and afterwards constantly dispersed thro' all the other parts, which we shall presently enumerate. This spirit seems to be the oily, and more subtile part of the vegetable, acted on by the force of fire. (2.) Water, which is here contained in great plenty, as residing in this spirit, in the first limpid, and in the second milky liquor, as also in the saline spirit, the volatile salt, and in some measure in the oil itself. This water can scarce be rendered pure by any art; being always fouled with the unalterable bitterness, and the inseparable disagreeable odour of the spirit. (3.) A sharp, volatile, alkaline, oily salt, which first comes over, rises into the receiver, and sticks to the sides thereof; for this salt is truly alkaline, as appears by its taste, smell, fiery virtue, the violent effervescence it makes with acids, and by concreting therewith into a compound salt: and hence a volatile alkali continually impregnates the atmosphere, in great plenty, by conflagrations. (4.) A sharp, alkaline, fat spirit, consisting of the salt just now mentioned, dissolved in water, and so resembling spirit in fluidity, pungency, subtilty, and volatility. (5.) A fetid, black, bitter, nauseous, inflammable, thick, and almost caustic oil, mixed with an oily salt. (6.) A true sal-ammoniac, sticking in the lower part of the neck of the retort, and raised to the surface of the black earth below. For if this salt be carefully collected, and separated from the alkaline kind, that first comes over, it proves a genuine sal-ammoniac. It is of a whitish colour, somewhat transparent, makes no effervescence with acids, and, if mixed with fixed alcalies, presently affords a true, volatile, alkaline salt, as sal-ammoniac does; whence the true origin of this salt is derived from foot. (7.) A black, fixed earth, which being afterwards calcined in an open fire, and burnt from its oil, that tenaciously cleaves thereto, leaves a white earthy calx behind.

This is the analysis of foot, by considering of which we may learn what parts of vegetables are volatile, and fly off by an open fire, and what are fixed and remain behind; and what fire throws off from vegetables into the air. Hence we see, that even earth, which appears so fixed in the most violent fire, after being separated from the other principles, yet when mixed with the rest, is either by the force of flame, or fire, thrown to the distance of forty feet thro' the air, in the form of a thin cloud; but there would be no end, if we should minutely pursue the physical uses of this process. Pills composed of dry foot, and gilded, are recommended for the cure of cold distempers, and this often with success. The volatile salt of foot is used with the same success, as that of animals. *Hartman* recommends the salt that rises last, for giving relief in cancers; and certainly sal-ammoniac, prudently employed, is of service against the putrefaction of running cancers. But the foot produced by oak-wood alone, the common *Dutch* turfs or pit-coal, appears different upon chemical analysis: and that again would be very different, that should be collected from the chimney of a public kitchen, which is continually filled with the fumes, not only of the fewel, but likewise of all kinds of boiled, roasted, and fried meats. And thus much may help us to form a right judgment of foot.

PROCESS

PROCESS LXXXVII.

The analysis of amber.

TAKE a capacious glass-retort, with its neck cut off, so as to leave an orifice two inches wide or more; put into it pieces of common amber, well cleaned from sand, dust, or other foulness, so that it may fill two thirds of the cavity. Apply a large receiver, and lute the juncture with the common luting; distil in a sand-furnace, with a degree of heat a little greater than that of boiling water; thus there will come over a copious, thin, limpid oil: continue this degree of heat so long as any oil comes over, and keep it separate. Then apply the receiver again, and cautiously raise the fire, till a second oil begins to rise, which will be yellow, large in quantity, and still transparent: proceed patiently with the same degree of heat, so long as this oil comes over, which it continues to do for a considerable time: but for the elegance of the operation, this also might be kept separate. Now, again, raise the fire gradually, till a white, saline, woolly matter appears in the receiver, but particularly in the neck: then gradually raise this fire a little, and continue it increasing, till no more of this matter comes over; but the fire must not be increased too quick, otherwise the volatile salt would mix with the gross oil that should follow after, and thus be in a great measure lost therein. It is best to remove the receiver, take out the productions, and keep them separate; but during the whole time that this volatile salt rises, a red oil also comes over, still almost transparent. The fire being now increased to the utmost, there comes over a gross, viscid, fat oil, thick like turpentine. When this is risen, if a fire of suppression be given, the whole black matter, now becoming flatulent, rises into the neck of the retort, and thus comes into the receiver, in form of a hard, black mass; so that if the neck of the retort is not left wide, it will be thus blocked up, and the glass be burst in a dangerous manner, with a loud noise, and often a firing of the matter. But if before the fire of suppression was used, a large quantity of sand were thrown upon this last remainder, it will divide the matter, and cause it to come over, without danger, in a black and dry form. There remain at the bottom of the retort, a very small quantity of brittle faces, of scarce any significance; so that the whole is volatile. If the operation be carefully performed, so many different productions are obtained, which may be purified by a new distillation, and be rendered thin and limpid; but the volatile salt, collected by itself, is perfectly acid. And this is the only method that I know wherein a true acid is obtained in a solid saline form; for we have no instance thereof in any other vegetable, animal, or fossil substance: For tartar is a salt scarce soluble in water, tho' it be acid. Oil of vitriol, brought to an extreme degree of purity, shoots in winter time into transparent solid crystals, but immediately dissolves again, and appears fluid as soon as the cold is a little diminished: but the salt of amber long continues the same.

The use.

Amber thus appears to be a very particular body; its oil resembles the fossil ones of *Petroleum*, *Naphtha*, and the like; but the remainder, after the first or second is come over, nearly resembles jet; and the acid salt seems somewhat vitriolic. Hence I have had a doubt where to place its analysis; at length I placed it here as doubtful; that it might be resolved into its parts; the rather because it almost entirely dissolves in alcohol, without separating into its parts, as in the fifty-eighth process. But the same thing concreted wonderfully differs from those parts, into which chemistry resolves it. Who will think that amber, its powder, its liquid solution in pure alcohol, the powder precipitated from its tincture with water, after distillation, and then washed; the oils, salt, and colophony, after distillation, proceeded from the same matter? Who could know the proper virtues of each; and who, by joining them together again, could recompose amber? The oils, being purified by a repeated distillation, have a sharp, balsamic, exciting, diaphoretic, diuretic, emmenegogic, and hysteric virtue; and, when externally used, in the way of liniment, are very serviceable in restoring contracted, weak, paralytic, torpid limbs: the volatile salt is gratefully acid, balsamic, unctuous, penetrating, preservative, and stimulating to the nerves and spirits, being a true, volatile, acid, oily salt; and therefore a capital anti-hysteric and diuretic; especially, if purified by a second distillation.

PROCESS LXXXVIII.

The Putrefaction of vegetables.

IF the soft, fresh, and juicy parts of vegetables, be in the summer-time thrown into an open cask, and pressed down therein, that the vessel may be almost full, and then left thus in the open air, they will soon of their own accord, begin to grow warm, and continue to do so more and more every day, especially in the middle. This heat, at length, increases above that of boiling water, and proves so much the more violent, the more the matter was compressed, and the less aqueous the plants, provided they were not dry. After this heat is arrived to its height, it again decreases by degrees, and returns to the temperature of the atmosphere: and by this means, the whole mass of vegetables is reduced almost to an uniform, pappy mass. This heat begins in the middle of the heap, where it is greatest, and thence spreads itself every way, till at length it possesses the whole. It makes no difference what plants are employed for this purpose, whether the most alealine, as scurvy-grass, the most acid, as sorrel; or the most insipid, as grass. These plants first breathe their own odour, if they were fragrant, so long as the heat continues small, or not above eighty degrees; and so long their particular taste remains; but as the heat becomes gradually greater, the natural odour is changed into that observed in hay that grows hot, upon being stacked too

wet;

wet ; and lastly, the heat coming to its height, all the peculiar smell, taste, and even the colour of the plant is lost ; a putrid, fetid, stercoraceous smell, and a cadaverous, putrefied taste, resembling putrefied urine, are produced, the presiding spirit is lost ; and the smell and taste are the same, tho' the plants were ever so different. If the plant be fresh cut, half dried, or still otherwise, retains its natural juices, and be thrown into large heaps, a sharp and very diffusive odour will first arise ; which shews that the fiery motion is beginning in the inward part of the heap, where the compression is the greatest, whilst no heat is yet perceived on the outside. If now the whole heap be thrown abroad, and the plant cooled, the putrefaction is presently stopped ; but if left to itself in the heap, the heat increases, so as to rot all the inside, boil in the middle, and at length break out into open flame ; and the larger the heap, and the greater the weight, the sooner this putrefaction and fire is produced. If the matter thus takes flame, it is changed, as it would be, by burning under a chimney ; but if it be strongly heated, tho' not so far as to fire, it then perfectly putrefies into a pap, as in the case we have described : and hay is too frequent an example hereof. This action comes on the slower in vegetables, the more dry they are of themselves, or the more they have been dried ; but if moistened with an additional quantity of water, so as to grow thorowly wet, the putrefaction will renew in them again. It also proceeds the slower, the lighter the matter lyes upon itself, so as to leave spaces that admit the free air ; but it proceeds the more strongly, the softer the subject, and the more violently compressed. Whence the drier plants, such as rosemary, being put up into a cask, will scarce putrefy in the manner above described, unless strongly pressed down by weight, or unless the heap were large. On the other hand, if too aqueous, a certain corruption, but not this heating action, is usually produced. If this pappy mass, so prepared, be immediately put into a large glass body, and distilled, with the junctures well closed, almost to dryness ; a limpid, fetid liquor will come over, that should be kept separate. Put the remainder, now almost dry, into a glass retort, and distil with degrees of fire, to the highest that can be given in sand ; and thus it affords white fumes, a large quantity of liquor, a white salt, and a black thick oil ; all to be kept apart. There remains behind a very small quantity of black faeces, which being taken out, and burnt in the open fire, leave a mere earth, without any fixed salt behind ; tho' this salt might be obtained, in plenty and perfection, from the same plants before putrefaction.

If, when the oil is separated, the last liquor be, with a gentle fire, distilled, in a tall vessel, to an half, it affords a sharp, alkaline, saline, volatile spirit ; which again being distilled to an half, becomes much stronger. And if the operation be repeated in a close vessel, a liquor will at length be obtained, extremely like rectified spirit of hartshorn : and afterwards by a gentle fire, a true volatile salt, in greater plenty than the plant would have afforded, of fixed salt by burning, before putrefaction. The like spirit and salt may be also obtained in the same manner, from the former liquors ; and when thoroughly purified, they perfectly resemble the volatile

‘ tile salt, and spirit of animals, without the least chemical difference ; and
 ‘ this happens, even tho’ the plant were of the most acid kind. The oil,
 ‘ forced over by the last extremity of the fire, is black, thick, and intoler-
 ‘ ably and lastingly fetid ; in which respects, as also in its pitchy tenacity, it
 ‘ extremely resembles that which, by the utmost violence of fire, is separated
 ‘ from animal subjects.

The use.

The action above explained is called putrefaction ; which, without the assistance of art, spontaneously happens in vegetables, as often as they are thrown on large heaps, or compressed in a moist state. This action is general, and converts all vegetable subjects into the same matter, how different soever they were at first. It also makes the whole of them volatile, except a little earth ; whence no operation more fills the atmosphere with sharp and often pestilential effluvia ; as we may learn from the fetid smell of putrefied bodies, which spreads so wide, and gives men notice to beware of such infected places. And as this putrefaction intimately resolves both the fluids and solids, sooner or later, into a liquid, soft, soluble mass ; it easily appears that by means thereof, and by the assistance of diluting rains, all things may be returned into the pores of the earth, from whence they before proceeded : or else, being carried up into the air along with the dew, mist, hail, snow, or rain, be again returned to the earth : or else putrefying thereon, sink into it along with the water that falls in rain. And in all art or nature we find no operation so universal ; as acting upon every vegetable in the same manner, with the same effect ; and reducing acid, austere, alkaline, aromatic, hot, cold, oily, phlegmy, and saline plants, to the same thing ; thus absolutely abolishing all their particular structures, odours, tastes, colours, virtues, and making them all alike. The soft matter it brings them into is liquid, of a gray colour, and perfectly resembling that gangrenous corruption, which is observed in putrefying, and rotting animal flesh ; or approaching nearly to that change, which vegetables undergo in the living bodies of healthy animals, whilst putrefied and discharged in the way of excrement. And the stronger the vital power of the animal is, or the more violent, thro’ motion ; or a fever, the nearer will the effects upon the vegetable aliment approach to the true vegetable putrefaction. Certainly, of all the natural and artificial operations, putrefaction best explains the first action of the mouth, stomach, and intestines ; whence that opinion is not to be entirely condemned, which makes the aliment to be there principally changed by putrefaction. This putrefaction is carefully to be distinguished from fermentation ; the rather, because artists every where too much confound them, to the detriment of arts. The differences appear to be these, (1.) A greater grossness, compression, and density, seems required in the putrefaction, than in the fermentation of vegetables. (2.) Putrefaction acts upon all vegetables whatsoever, provided they be soft and juicy ; but fermentation only upon some, and not upon others. (3.) The heat required in putrefaction spontaneously rises from the degree of an healthy human body, even to that of a violent flame ; but in fermentation, if the degree of heat rises up to that of an healthy

healthy body, the fermenting cause is dissipated, and the liquor turned vapid; for the heat, generated by fermentation, is not greater than that of seventy five degrees, except in the fermentation of vinegar; and even there, unless the heat be immediately stopped, no vinegar, but a corrupt vapid liquor will be obtained. (4.) Putrefaction renders all the saline matters volatile and alkaline, the oils fetid and volatile, and almost volatilizes the earth itself: but fermentation makes acids volatile, and subtile; and, contrary to alcalies, spirituous, gratefully odorous and inflammable: it generates an acid tartar, that leaves an alkaline matter, as fixed in the fire as the subject would have done before. (5.) The salts that by putrefaction are of the same simple, alkaline, fetid, volatile nature, are by fermentation acid, in great measure fixed, and compounded of spirit, oil, and earth. (6.) Putrefaction is a means of entirely converting all the saline vegetable matters, into one and the same simple, volatile alcali; but fermentation converts only a certain little part of the saline matter of vegetables, into a liquid, volatile acid, leaving the rest almost unchanged. But if after well considering all these particulars, any one shall think, that the two operations should not be distinguished, to prevent multiplying differences without cause, I have no opposition to make; as not knowing what other kinds of arguments to use in chemistry. Fermentation, with a small degree of heat, resolves the latent air, which, with the assistance of the other elements, attenuates, moves, and dissolves the viscid parts of the fermentable subject, during a certain space of time, so as to make a continual ebullition, and either to set free, or generate an inflammable spirit: but putrefaction, by a stronger heat, agitates, and expels the same air suddenly, and so changes the whole matter. It must be observed, that we have here spoke only of vegetable putrefaction. And here we end our processes upon vegetables; as this last has changed them into a form similar to that of animal juices, to which we are therefore led: but for more upon the subject of putrefaction, see the excellent Dr. Cox's papers in the *Philosophical Transactions* (a).

(a) N^o. 100, and 101.

PART

PART II.

Chemical Operations upon ANIMALS.

PRELIMINARIES.

IT appears by the preceding eighty-eighth process, that vegetables may be, and frequently are changed into one and the same almost undistinguishable substance; without any difference, whether the subject were acid, alkaline, bitter, aromatic, insipid, poisonous, &c. and the same thing happens in the vegetables received by animals as food. Hence therefore the preceding processes upon vegetables will lead us to understand, what chemistry may perform upon the parts of animals: but to proceed herein with better advantage, we must here lay down a few particulars from medicinal history.

1. All the known animals continually waste, in all the solids and fluids whereof they consist at a certain time: this appears from the hair, nails, external skin, the extremities of all the vessels, the internal sides, and the external surfaces thereof. This continual loss is occasioned by the discharge of very fine worn off particles, that do not appear, or else are esteemed as fluids. And thus the perspirable matter, the sweat, the saliva, urine, milk, &c. are continually thrown off from the bodies of both sexes. Fractured bones are joined again in a few weeks, even tho' part of their substance were lost; which evidently shews that even this solid part is in continual motion by means of the vital powers.

2. Animal bodies therefore do not in this respect remain the same that they were, but new matters are daily supplied, in the room of those discharged, by means of the food, and perhaps of the air taken in; for *Bellini* has observed, that eggs gain in weight whilst sat upon by the hen. Hence it is manifest by what the body is nourished, as it grows from a weight scarce exceeding that of a grain, to the bulk we find it at full stature: for, certainly, its growth proceeds from what is taken in, changed, worn off, and repaired by the vital powers.

3. The food of animals is either derived from vegetables, or from other animals, and their drink from the same, or from water. Fossils contribute nothing to this purpose, unless it be salt; tho' life may be preserved without it, as appears by the examples of whole nations, the *Brachmans*, *Pythagoreans*, and others, who lived wholly upon vegetables and water, and were healthy and long lived.

4. Most of the animals used for human food generally feed upon vegetables, such as oxen, deer, sheep, goats, hares, &c. The larger fish, indeed, feed upon the less, or upon insects; and some birds of prey feed upon other

other creatures or insects : yet vegetables generally give origin to the aliments of animals, either first or last. Whence we have first examined vegetable subjects, in the preceding eighty processes.

5. The human body, therefore, consists of a collection, chiefly of vegetable matters ; for tho' we use milk, cheese, butter, and flesh, yet the creature, that affords them, was before made up of grass, hay, and water.

6. The chemist, before he examines an animal body, which is wholly fed by vegetables, should first understand what vegetables are, when treated by his art. If this be neglected, he will err in the knowledge of animal bodies ; and hence it is that so much confusion has arisen in this matter.

7. When all the changes of vegetables, producible by the art of chemistry, are explained ; the nature of that animal matter is first to be examined, in the chemical treatment of animals, which being of a vegetable origin, begins to lose its own nature, and to put on that of the animal ; and this part is to be such as may be obtained and examined separate, so that the successive change may be understood ; and chiefly whilst it retains much of its former nature ; for thus the nature of the animal will by degrees be better learnt, especially that of the human body, for the sake of which all the labour is undertaken, than if a part, which had already undergone the actions of the whole body, were immediately chose for the first examination, as it usually preposterously is.

8. An animal is composed of matter, which was not that animal before, but is changed into it by the vital power of the animal. This may be known by beginning with the first change above-mentioned, and proceeding gradually thro' all the successive natural changes, in their true and proper order. After long considering where to begin these processes, at length, I found, they could not begin with the contents of the stomach ; because the matter, as soon as it is herein changed, goes out in the form of chyle : and the contents of the intestines want the part that was so changed. The chyle of the mesentery, or thoracic duct, can scarce be obtained in sufficient quantity ; and, besides, it is in great measure the lymph of the lymphatic vessels. Milk, therefore, appeared to be the first thing to be examined ; for this is a true chyle, and much less diluted with the lymph than the chyle when poured into the subclavian vein, and therefore approaches nearer to the aliment. It has flowed thro' the veins, the heart, the lungs, and the arteries, and therefore been mixed with all the juices ; and being afterwards separated by the particular structure of the breasts, it may be collected and examined apart. Milk is a liquor prepared from the aliment chewed in the mouth, digested in the stomach, perfected by the force and juices of the intestines, and elaborated by means of the mesentery, and its glands, and juices, and the juices of the thoracic duct ; it has undergone some actions of the veins, arteries, heart, lungs and juices, and begun to be assimilated, yet may still be had separate, and discharged out of the body.

9. And thus by their own milk, prepared from the proper matter of the chyle, all the known animals that have milk are nourished, both male and female. For milk is always prepared from the chyle, as well in men, as in women, as well virgins and barren women, as in mothers and nurses.

Whence every such animal consists, is nourished, and lives on its own proper milk; and from this alone prepares all the other parts, both the solid and fluid, by means of the vital actions. It is also certain, that men may live for years by feeding upon milk alone, and perform all the actions of life, and have all the solid and fluid parts of their bodies perfectly elaborated. The serum, therefore, the blood, the lymph, the spirits, bones, cartilages, membranes, and vessels, proceed from milk; and if a man may live for years upon milk alone, milk must contain in itself the matter of all the parts in the human body. Milk approaches nearer to an animal nature than chyle; the chyle of the intestines is nearer to a vegetable nature, and that of the stomach nearest: and hence we find the phenomena of fermentation and putrefaction in the stomach and intestines; such as acid eructations, fetid smells, and the like; for this chyle is a true emulsion, prepared by the grinding of the teeth, the tongue, the stomach, and the intestines, along with the saliva, the liquor of the stomach, the pancreatic juice, and bile, in the intestines: and hence proceeds milk.

10. If this milk be good, and suffered to rest in a clean vessel, it first appears uniformly white, then throws up a white, thick, unctuous cream to its surface, and remains somewhat bluish, more transparent, thin, and less unctuous below. If the cream be carefully taken off, the remaining milk produces more, but retains a certain quantity behind. The same thing happens in emulsions; the milks of all the known animals have this property alike, as likewise the property of whiteness. The human milk is very sweet and thin, the next is that of asses, then that of mares, then of goats, and lastly of kine. Whence it is prescribed in this order to consumptive persons of weak *viscera*. But tho' milk resembles vegetable emulsions in several respects, yet it is not the same thing therewith. The rennet, prepared of the juice in the stomach of such creatures as chew the cud, being mixed with milk, coagulates it into an uniform mass, that may be cut with a knife, and it thus spontaneously separates into whey, and curd; but this does not happen in emulsions. If long boiled over the fire, it loses its more fluid part, and condenses into a butyraceous and cheesy mass; but not into an uniform one that will cut like the dry'd serum of the blood, or white of egg. It has a pleasant taste, and no unpleasant smell; it is extremely mild, and of a middle nature between the blood and the chyle; and hence proves different according to the aliment, and the creature that prepares it. Having laid down these particulars, we come now to examine it.

P R O C E S S LXXXIX.

That recent cow's milk is neither acid nor alkaline, remarkably saline nor spirituous; by means of the forty-fifth, forty-sixth, forty-seventh, forty-eighth, and forty-ninth processes.

NEITHER the smell, nor taste, nor the dropping of new milk into the eye, manifest any acid, alkaline, or saline matter to be contained

‘ tained therein. If the milk be heated, and successively mixed with pure
‘ volatile and fixed alcali, there arises no effervescence, that shews any aci-
‘ dity; but the milk grows somewhat thick and turbid. To other parcels
‘ of the same milk add the acid spirit of vinegar, of nitre, of salt, and of
‘ vitriol, and these make no effervescence, so as to manifest the milk to be
‘ alkaline, but thicken and coagulate it. But upon mixing milk whereto
‘ oil of tartar *per deliquium* was poured, along with some oil of vitriol, there
‘ immediately arises a violent effervescence, and much greater than if the
‘ same quantity of alcali was added to pure oil of vitriol. If new milk be
‘ distilled in a glass alembic, with a fire of about a hundred and sixty degrees,
‘ there comes over an aqueous liquor, without any signs of an inflammable
‘ spirit; nor does this liquor give any chemical sign of being either acid, or
‘ alkaline, upon mixing with either acid, or alkaline salts. It also appears
‘ not to contain any trace of a saline matter; being inodorous, and perfectly
‘ insipid, and causing no pain if dropped into the eye. There remains
‘ behind a yellow, thick, unctuous mass, of a sweet and grateful taste, which
‘ mass gives not the least appearance of containing any thing acid, alkaline,
‘ or saline, upon all the trials made to discover it.

The use.

This is the true nature of milk, thus variously examined; whence we here find no signs of a perfect fermentation, either of the acetous, or vinous kind; nor of putrefaction, which produces an alkaline salt, or fetid oil; and this tho’ a great part of the animal juices be mixed with the vegetable matter of the milk. Whence we must form a very different notion of the action performed in the making of chyle and milk, than chemists usually suppose and deliver. And as cattle are milked twice a day, this whole operation must be performed in the body in the space of twelve hours; and if detained longer, it begins to degenerate and corrupt. This experiment was made with cow’s milk, because they feed wholly upon grass, hay, and water. There is, sometimes, a difference found in women’s milk, from the difference of the aliment; but, when fresh, there is little difference to be observed. Some have supposed that there was here a latent acid, tho’ it did not appear upon the preceding experiment; but if acids are denominated with respect to our senses, or their sensible effects, there is no acid contained in recent milk.

PROCESS XC.

Fresh cow’s milk coagulates with acids, even in a boiling heat.

‘ **L**ET new milk boil in several different vessels, with the addition of a
‘ little water to prevent its growing too thick in the boiling; pour
‘ into one of them a little vinegar, and one part of the milk will presently
‘ coagulate, and leave the other fluid. Into a second pour the spirit of
‘ nitre; to a third, spirit of salt; and to a fourth, the oil of vitriol; and
‘ the same effect immediately ensues: nor can this coagulation be prevented

The Practice of CHEMISTRY.

‘ by a heat of two hundred and twelve degrees. The same coagulation is
 ‘ made with any other acid, as the juice of sorrel, barberries, citron, cur-
 ‘ rans, verjuice, tamarinds, and tartar; so that the thing, which of itself
 ‘ was so liquid, as to pass thro’ the finest arteries, now has one part sepa-
 ‘ rated into a gross, curdy matter, and another into a much thinner than
 ‘ the milk itself, called whey. If the curd be strongly pressed betwixt a
 ‘ thick linen, it makes cheese; which consists of the cream of the milk and
 ‘ the curd. This cheese, with age, becomes sharp and biting, not acid,
 ‘ but rather somewhat alkaline, of a particular smell, and so penetrating a
 ‘ taste, as often to inflame the mouth. But when the milk is first deprived
 ‘ of its cream, and afterwards coagulated with acids or with rennet, the
 ‘ cheese, thence made, proves very dry and hard like horn; and when ap-
 ‘ plied to the fire grows tough, scorches, fries, burns and smells perfectly
 ‘ like horn. This is a strange change of so fluid a matter as milk, but is,
 ‘ perhaps, the origin of all the solids in the body.’

The use.

The nature of milk, thus discovered, is the same in the receptacles of the breasts, where it is lodged, and therefore may be there coagulated by a like saline, or acid matter; at which time the thin serum comes out at the nipples, and the thick curd remains in the vessels, so as there to produce hardness, swellings, inflammation, suppuration, scirrhusities and cancers; and, perhaps, the same may happen in the chylous glands of the mesentery. But in all these coagulations with acids, the milk retains its white colour; and hence appears the reason why weak constitutions make a white chyle and milk, but with difficulty convert it into a red blood; whence such persons abound with acid, are troubled with acid eruptions, their sweat and smell being also acid, and the whole body pale; which particulars being considered, may lead physicians into a due understanding of many diseases.

PROCESS XCI.

Recent cow's milk coagulates, turns yellow, and red, by boiling over the fire with fixed alkali.

‘ **D**ILUTE new cow's milk with a little water, boil it in a clean ves-
 ‘ sel, and by degrees drop oil of tartar *per deliquium* into it; it will
 ‘ thus begin to turn yellow, the more so as more alkali is added, and the
 ‘ boiling the longer continued, so as to pass from a faint yellow into a red
 ‘ colour. At the same time it coagulates more and more, and separates into
 ‘ curdy masses, tho' not so large and firm, nor so easily hardening, as those
 ‘ produced by acids. At length by boiling the whole long enough, it be-
 ‘ comes a thick, red, coagulated mass.

The use.

Milk, therefore, which, mixed with acid, or its own rennet, retains its white colour, even in the heat, immediately turns yellow, with alkalies, in
 a strong

a strong heat, and if the heat be sufficiently intense, almost red. When a woman that gives suck becomes highly feverish, the milk in the breast is corrupted, and in this case it becomes yellow, saline, thin and sanious; the coagulated thick part, remaining in the breast, now grows somewhat fetid, and is abhorred and loathed by the child. When therefore the milk coagulates in the body, and grows yellow under a fever, the physician must not suppose it coagulated by an acid, but by too much heat, and rather by an alkaline tendency: and, perhaps, physicians find the milk thus coagulated by a fever, a hundred times for one where it is coagulated by an acid. And in the last contagion among the cows, whilst their meat remained in the stomach, and was neither discharged upwards by ruminating, nor expelled downwards, and therefore truly putrefied with the violent degree of heat, so that the stomach was almost scorched with heat, as we explained the thing under the eighty-eighth process, then the milk grew sharp, yellow, somewhat fetid, and thin in the dug, and in this form was either milked out, or dropped spontaneously. And thus, if when milk is coagulated either by chemical acids, or by rennet, and heated, and alkali be put thereto, we shall find that false which is every where asserted, viz. that alkalies should dissolve the coagulation, and recover the former fluidity. And hence we may understand how milk will long remain white in the weakest and coldest constitutions, and not be brought to the natural redness of blood. And hence such persons are continually pale, and their blood thin, pale, and watery; and upon the removal of the disorder the whiteness vanishes, and the red colour returns. So when the vital faculties are but moderately strong, they are only able to convert some part of the milk into blood, but not to perfect the whole; in this case there arises a somewhat pale, yellowish, or greenish colour, whence the green-sickness in virgins: but where the vital faculties are robust and strong, so that they briskly circulate and heat the milk, the white colour is soon subdued and turned into an highly red one; whence the blood shall often be so intensely red, as to appear almost black. Lastly, it is manifest that the white colour of the milk may remain in the body that abounds with acids; but if alkalies preside therein, it will gradually acquire, first the colour of bile, afterwards grow more intensely yellow, and tend to redness. Doctor *Lower* has shewn that the white colour ceases, twelve hours after feeding.

PROCESS XCII.

Urine is neither acid, nor alkaline, but fetid.

TAKE the urine of a man in health, made twelve hours after eating or drinking, which must therefore have remained so long in the body, and have circulated almost the same time therein, and have been mixed with nearly all the juices in all the vessels, by means of the vital powers. It is therefore an aqueous lixivium, that has washed away, and brought off with it, whatever would dissolve in water, and run thro' the fine urinary vessels of the kidneys: particularly it contains the spirituous
saline

‘ saline and saponaceous matters of the blood; and when thus long retained
‘ and digested, it acquires the true nature of the body, as being wrought
‘ upon by the vital powers for twelve hours successively; at which time the
‘ milk has lost its own nature in the body, and now begins to be converted
‘ into the serum of the blood. And for this reason such urine should be
‘ chose as is well concocted, and discharged at twelve hours distance from
‘ feeding, the thinner and more crude being come away before. Such urine,
‘ therefore, may always be collected without the body, and yet retain and
‘ perfectly exhibit the nature of the animal juices, and their principles. This
‘ urine is not acid, because it neither tastes nor smells sour, nor gives a red
‘ colour by mixing with those juices that turn red with acid; and lastly,
‘ because, if heated and mixed with oil of tartar *per deliquium*, it affords not
‘ the least sign of effervescence. And if another part thereof be heated and
‘ mixed with the alkaline spirit of sal-ammoniac, it manifests no sign of
‘ effervescence; nay, what seems stranger, the urine of a man who drank a
‘ large quantity of *Rhenish* wine, which is considerably sour, and also of sour
‘ beer, used much vinegar in his sauce, and eat largely of fruit, did not
‘ afford the least signs of acid, upon any experiment, twelve hours after eat-
‘ ing. So likewise the urine discharged by young female persons of weak
‘ constitutions, that use little more than acid vegetables and milk for their
‘ meat and drink, manifests no acid twelve hours after meals; the natural
‘ powers therefore have in this time conquered that tendency which vege-
‘ tables had to acidity, or else the acid that was in them. *Helmont*, there-
‘ fore, justly said that acids were enemies to the veins; but his followers
‘ hence unjustly forbid the use of acids in diet and medicine, as if they were
‘ poisonous, supposing them prejudicial to the first passages. These expe-
‘ riments will be allowed by chemists; but it may, perhaps, move them to
‘ hear that there is no manner of alkali contained in this urine, and yet the
‘ thing is certain; for if to separate parcels of this heated urine, there be
‘ successively poured vinegar, lemon-juice, spirit of nitre, spirit of salt, and
‘ oil of vitriol, no effervescence ensues; but these acids, mixed with warm
‘ urine, discharged at the distance of twelve hours after eating, unite there-
‘ with, as water unites with water, without bubbles, and without hissing.
‘ Such urine also does not turn the juices of herbs to a green colour, as all
‘ alkaline salts do.’

The use.

Hence we may collect, that the powers of the body change acids, so
that they remain no longer the same, and prevent things disposed to aci-
dity from becoming acid; and that in health, alkaline salts are never pro-
duced, but only such as are neutral. And this I have observed in the urine
of persons in high fevers, and inflammatory diseases, where the vital actions
being increased, rendered the urine flame-coloured, fetid, sharp, and little
in quantity: for even such urine, examined by the methods above-men-
tioned, gave no signs of its being alkaline: whence I was led to consider
whether in a perfect stoppage of urine, where this liquor is long detained,
heated, and agitated in the body, it would not become alkaline. And it
happened

happened that an eminent person in years, falling into this distemper, which proved fatal to him, had no discharge of urine for five days, but on the sixth, suddenly made a few ounces, that was red, turbid, and of a fetid smell; but he had hence no relief, and made not a drop afterwards, but died. This urine I directly carried home with me, and presently examined by the known chemical methods, none of which shewed it to be alkaline; whence I understood that urine could not become alkaline in the space of a hundred and twenty hours, tho' agitated by the heat of the body, and the action of circulation: for in the patient above-mentioned, the bladder contained no urine; and I have never found any of the humours in health to be alkaline, tho' they may become so from other causes: nor did I ever find them alkaline in the most putrid diseases, whether acute or chronical. I remember once an ancient corn-merchant had a large stone in his bladder: but being not a fit subject to be cut for it, his urine would often, when he was in exquisite torture, smell alkaline; and as he had frequent stoppages, a skilful surgeon was obliged often to put back the stone from the neck of the bladder, with a catheter, towards the bottom; but being once absent, the patient continued in pain, without making water for several hours; but the operator returning and performing his usual office, the urine came out so sharp, alkaline and putrefied, and with such a peculiar stench of digested urine, that the surgeon inadvertently drawing the vapour thereof into his lungs, was thereby disordered for some days. Whence I conceive, not having any opportunity of examining this urine, because it was spilt, that, being attracted into the pores of the spongy stone, and lodging therein, it was thus digested by the heat, and so, perhaps, acquired a true alkaline acrimony: however this were, it is certain that the urine contains no native alkaline salt, and, consequently, no other humour of the body; because the urine holds more salts than any other animal liquor; and because the salts of the urine are more acrimonious, and easier rendered alkaline, than of any other liquor in the body. Whence those artists are greatly deceived, who so loudly cry out against the natural, volatile, oily, alkaline salts in the body. This is an error introduced into medicine, by an imprudent cultivation of chemistry, which the more prudent cultivation thereof must correct: the fetid smell of urine in health is therefore entirely owing to the attenuating, putrid, and volatilized oil, which is inseparable from it; and not to a volatile, alkaline salt. Its bitter, nauseous, and saline taste, is owing to the compound salt of the urine, and to the oil, as also to the sea-salt which urine generally contains.

P R O C E S S XCIII.

Fresh urine, distilled in a close vessel, affords a fetid, nauseous water, neither alkaline, acid, saline, nor vinous.

‘ TAKE well concocted human urine, discharged in health, and distil
‘ it in a glass body, with a gentle fire of a hundred and fifty degrees,
‘ uniformly kept up, till only a twentieth part remains behind. There
‘ will come over a limpid water; the urine in the mean time gradually
‘ changes

changes from its natural straw colour, to red; and the more of this pellucid water comes over, the deeper that red colour appears; and at length the remainder becomes of an almost black red, very thick, turbid, opaque, frothy, and tenacious. The first limpid part has a particular nauseous smell, but not that of a volatile alkali; but what seems strange, tho' it be often distilled over again, yet it always retains this nauseous odour, and even tho' it should long stand in the open air. This corrupt odour, therefore, is inseparable, and intimately mixed with the liquor, so as not to be destroyed even by the addition of an acid. It seems to resemble nothing more than that disagreeable exhalation, which arises from wounds in the *abdomen*, or the carcass of a man fresh opened after a violent death. The nauseous taste of that water, tho' somewhat putrid, is not alkaline, or any way saline, howsoever it be distilled. Again, in the distillation thereof, there appear no veins upon the glass still-head, as in the distillation of vinous spirits; and if the water that first comes over be a second time distilled, neither thus will the least quantity of any such spirit appear; and tho' ever so carefully rectified, it has, so often as I have examined it, never took flame, but always quenched fire. Even the urine of such men as are great drinkers of strong liquors, such as wines and distilled spirits, never affords any thing inflammable. When this first distilled liquor of the urine is mixed with acids, it never gives any signs of effervescence, nor changes juices green, as alkalies always do, nor considerably precipitates the solutions made with acids: and by no manner of rectification will it afford a manifest salt, nor ever change acids into a compound, neutral salt. Consequently it is no alkaline liquor: nor does it manifest the least signs of acidity upon any kind of experiments; as the addition of fixed and volatile alkalies, the various juices that turn red with acids, &c. Whence we seem to have proved our point.

The use.

We may learn many momentous particulars in medicine from this slight experiment. Thus, (1.) we see, the lightest, thinnest, and most volatile part of the healthy juices is nearly elementary water, excepting that there is inseparably joined therewith, that other equally light, thin, volatile, fetid, and seemingly corrupted matter, not proceeding from a saline principle, but rather from an oily one, and yet no way vinous or inflammable. (2.) Whence there is no fermentation in the juices, nor no production of inflammable spirit, which is easily separated from water; whereas this fetid part can by no means be separated from its water. (3.) Consequently there is no inflammable spirit in the vital juices of the body. (4.) Oil, by the vital powers of the body, is rendered much more volatile than any salt in the body, contrary to what is generally believed. This peculiar, fetid, oily matter is scarce otherwise found, than in the matter of perspiration, the sweat, and the vapour which naturally resides in the cavities of the body. Vinous spirits, when drank, do not go to the urinary passages, and may, therefore, rise to the head, disturb the brain, the common sensory, and the origin of the nerves; and hence, perhaps, they so wonderfully affect the actions of

of the *cerebrum* and *cerebellum*. And hence, perhaps, it is, that they so easily exhale from the body, possibly at the surface of the skin. Our present process also shews that there is no volatile salt in the body, capable of rising with this degree of heat, whatever chemists or physicians may think to the contrary; and that there is no volatile alcali, whether simple, or oily, nor any volatile acid in the body; so that the modern physick must be greatly corrected in these particulars. The fetid smell of the urine always increases and decreases, as the vital powers increase or decrease, in an healthy body; and the more the body is exercised by labour and motion, the more this fetid smell is always increased, and *vice versa*. If any thing in the animal juices is to be called spirit, on account of its acrimony, volatility, lightness, and penetrating virtue, it is neither vinous, nor saline, but really arises from an oil corrupted, or turned to such a putrefaction, as that described under the eighty-eighth process.

P R O C E S S XCIV.

The remains of the recent urine, after the preceding process, are neither acid, nor alkaline, nor truly saponaceous, but saline and fetid.

IF the gross remainder, after the preceding distillation, be mixed with any kind of acid or alcali, it affords no sign of effervescence, so as to appear either acid or alkaline; nor can it be manifested by any other experiment. It is indeed highly sharp, of a very saline taste, and a little bitterish, but not alkaline, nor has it an alkaline odour, but smells fetid almost as before. If used by fullers and wool-scourers, it neither cleanses nor deterges, and therefore has no saponaceous virtue, which it excellently acquires by putrefying. In this whole inspissation there appears no signs, either of chyle or milk. Nor have I, with the utmost attention, ever discovered the least of that coagulation, which the lymph and serum of the blood always run into by heat. And however treated, it manifests nothing of a cheesy nature, but constantly the more it is inspissated by the fire, the sharper and deeper coloured it becomes; and thus, by various degrees, it increases and changes in colour, thickness, and acrimony, the longer the inspissation is continued, so as to run thro' all that diversity usually observed in the urine, under acute and chronical distempers, as *Bellini* has excellently observed. In acute diseases, the hotter the fever, and the more it dissipates the moist parts, the redder, the sharper, and the thicker the urine becomes.

The use.

There is, therefore, naturally no fixed or volatile alcali in an healthy body, nor any fixed or volatile acid in the natural juices, whilst they remain sound; but this salt is of a particular nature, which we shall hereafter examine,

mine, and much less volatile than water, as not rising even with a boiling heat. It is surprising, that no nutrimental matter should ever be contained in this urine; for there is no chyle, milk, curd, serum, or *lympha* therein, which coagulate by fire; but physicians justly acknowledge these as the original matter of nutrition. Nothing nutrimental, therefore, is discharged the body along with the urine. Thus all the parts of the chyle, milk, blood, or the humours thence prepared, that become sharp, corrupted, subtil, unfit for nutrition, hurtful to the body, and, having performed their office, are at length separated by the vital powers, and by means of the kidneys discharged the body. Urine, therefore, exhibits the humours highly changed by the powers of the body, even so far as never afterwards to prove healthful thereto; and therefore the small quantity, the sharpness, colour, and thickness of the urine, afford many just informations to the physician, as indicating the necessity of water, demonstrating the condition and state of the humours, the remedies required in diseases, and what things are chiefly destructive to the body, by dissolving the texture of the blood, and how pernicious a great fluidity is.

P R O C E S S X C V.

Recent urine, inspissated to a fortieth part, and distilled with sand, affords an alkaline spirit, an alkaline, volatile salt, a very fetid oil, and saline fæces.

IF the distillation of the urine be continued, till of forty pounds thereof, first taken, there remains but one; or if the like recent urine be suffered to exhale in a low, capacious, cylindrical, open vessel, with an almost boiling heat, till only a fortieth part remains, there will be found at the bottom a gross, thick, blackish, sharp matter, which being mixed with thrice its weight of clean sand, and then distilled in a retort, in a sand-heat, by gentle degrees at first, and often examining the liquors that come over, by removing the receiver, a limpid water will first rise, as in the preceding process; and when the matter begins to be almost dry, another limpid liquor will come over, of a sharp, fiery, alkaline nature. Continue the operation so long as this rises, and keep it separate, then closely lute on a receiver, and urge the matter by degrees of fire, upon which white clouds will long continue to rise, and unctuous veins appear, whilst a somewhat oily, yellow liquor, together with a white, solid, and alkaline salt will rise. At last, with the utmost violence of fire, there comes over a yellow or gold-coloured oil, and when this ceases, a saline, feculent matter remains at the bottom. The first water is scarce alkaline, sharp, saline, or any way oily, but like the water of the preceding process: the second liquor has a sharp and manifest saline odour, it proves pungent and fiery upon the tongue, and has a perfect alkaline taste; it makes a violent effervescence with all acids, and when saturated with any acid,

acid, concretes therewith into a compound, neutral, half-volatile salt, like sal-ammoniac, but of a determinate nature, according to that of the acid. This salt, therefore, is truly alkaline and volatile, like that produced in the eighty-eighth process. All this appears more in the third unctuous liquor, which is much more intensely alkaline, tho' oily; and hence is usually called alkaline spirit, as consisting of water, salt, and oil mixed together. The whole salt is always alkaline, but rendered very ungrateful by the fetid oil adhering thereto. The oil, which comes over at the same time, and afterwards is highly fetid, and infects every thing with its odour, so as to be intolerable, and not only retains the smell of urine, but is somewhat stercoraceous. The remaining faeces being calcined in an open fire, and then elixated with water, afford a true sea-salt, if the person have used that salt in his food.

The use.

Hence it appears that the salt of urine, tho' not alkaline of itself, may be rendered so by a certain degree of heat, and that this urinous salt is not ammoniacal, because sal-ammoniac, tho' volatile with a certain degree of heat, yet when sublimed thereby, never becomes alkaline, but remains compounded, how often soever it is sublimed; whereas the salt of urine, tho' likewise of a half-fixed nature, and becoming volatile with a certain degree of heat, at the same time also becomes alkaline, and no longer retains the nature of a compound salt. It therefore approaches to the nature of alkaline salt, and sal-ammoniac, tho' itself be neither of them. Hence also we see, that the salt, saline spirit, and first oil, are almost equally volatile in a sound state: and that this unctuous spirit consists of water, oil, and salt, into which it may be commodiously resolved. And hence also we understand, how by the natural powers, the mild, white, indolent, inodorous, and unctuous matter of the aliment, chyle, milk, fat, and marrow, may turn into another that is sharp, yellow, inflammatory, thin, and fetid; whence also the fetid smell of the urine usually proceeds. Again, we hence learn, that there is no fixed alkali in the animal juices; for I never could find a grain thereof in the largest quantity of the urine thus treated. And lastly, that sea-salt may enter the blood, mix therewith, thence pass into the urinary vessels, and yet remain unchanged, so as to act thro' most of the vessels of the body, without suffering an alteration by their re-action. All which particulars being considered, our present experiment, which is owing to *Helmont*, will be found of infinite use in medicine.

PROCESS XCVL

Recent inspissated urine, distilled with fixed alkali.

FRESH urine being inspissated as before, pour thereon an equal quantity of the oil of tartar *per deliquium*, or the solution of pot-ashes, and there will instantly arise a sharp, alkaline, volatile vapour, such as usually

ally proceeds from well putrefied urine, when it grows warm. If the mixture be now immediately distilled in a glass alembic, with a gentle fire, there comes over a limpid liquor, running in veins, which proves sharp, highly alkaline, and more volatile than water, and in every respect resembling true and strong alkali. And when instead of the oil of tartar, the dry salt of tartar be used, a dry alkaline salt often rises first in this distillation. And when the former alkaline liquor is again distilled in a tall body, with a gentle fire, the part that first rises is saline, white, and alkaline; the oil remains at the bottom along with the fixed alkali added, as if it was more fixed thereby. Lastly, when all is become dry, if the fire be strongly kept up, there likewise comes over a fetid, yellow oil after the salt.

The use.

This experiment shews the nature of the animal, urinous salts to be such, that a fixed, alkaline salt can instantly change them, like the violent action of the fire, in the preceding process. And hence we learn, that fixed, alkaline salts, being mixed with the juices of the body, will presently render them sharp, alkaline, extremely moveable, and more volatile than the water and spirit of the body; communicate a fiery, corrosive nature to the spirits, and immediately give them a tendency to putrefaction. If the salt and saline spirit, thus produced, be several times distilled over again with a gentle fire, they at length become as purely alkaline as those prepared from hartshorn, or other costly substances: when mixed with acids, they make a violent effervescence, especially if shook together; and by this means are so mortified and changed, as to lose their sharpness, and all their alkaline or fiery nature; being thus also so fixed, as not to prove volatile with the heat of an healthy body. They lose the proper virtue of acting like volatile alcalies, especially that of almost mortally dissolving and attenuating the juices of the body. And what is more to our purpose, physicians may hence understand the surprisingly changeable nature of the salts of the body; how variously they may alter from their native disposition; and the proper effects of each alteration; and also learn the remedies and degree of correction which each requires: all which were known to the ancients from experience. Thus in fevers, attended with an increased heat and motion, *Hippocrates* allowed only of things tending to an acid nature, or actually acid, to be used as food, drink, or medicines: and hence we see, that fixed alcalies are destructive in the body, as often as attended with heat, motion, a fetid smell, a flame colour, or small quantity of the urine, or the juices are too much dissolved; so that in such cases to exhibit these salts, is highly dangerous, especially in the plague.

PROCESS XCVII.

Recent urine, especially when inspissated, affords a fiery spirit that is not alkaline, upon the addition of quick-lime.

IF quick-lime be thrown into recent urine, there instantly exhales a spontaneous vapour, which strikes the nostrils with an extremely pungent and fiery sensation; and if it be now directly and gently distilled in very close vessels, it affords a limpid water of an intolerable fiery odour, like the former, but much more sharp and volatile. And if, when the urine is first inspissated to a quarter part, an equal quantity of quick-lime be mixed with the remainder, the odour is much stronger, and the spirit, obtained by distillation, not to be equalled by any other for its sharp, fiery, subtile, and volatile nature. After all this spirit is separated by distillation, and the remaining mass afterwards treated by the same operation, it will never afford a solid salt, as in the preceding process; but always a very fluid, saline liquor: and whatever acid is mixed therewith, it causes no effervescence, tho' the fiery virtue and volatility are greatly diminished thereby. There is caution required in this process: for as soon as the quick-lime touches the urine, or the inspissated matter thereof, it excites a great ebullition, and a violent heat, and at the same instant the most sharp and volatile spirit hitherto known arises; and, being agitated with the violent heat, it is put into a furious motion, so that being inadvertently received into the lungs, it may instantly prove highly dangerous, and occasion an instantaneous inflammation in the tender vessels of the lungs, and directly communicate it to the blood circulating thro' them: for if this spirit be held to the external warm skin, it immediately makes the part gangrenate, and mortify; but, perhaps, the whole thickness, between the circulating blood in the lungs and the air contained in the vesicles thereof, is not the thousandth part of an inch: but this urinous spirit, prepared with quick-lime, suddenly exhales its sharp part in the open air, and leaves a water behind.

The use.

Hence we may learn the action of quick-lime upon the saline urinous juices of the body; for when assisted by heat, and the vital motion, it presently generates these fiery spirits, that prove destructive to the tender, pappy masses of the brain and nerves; and the hotter, or the more agitated the body, or the more it is affected with inflammatory disorders, the more destructive the use hereof. But when the body abound with acid, water, or phlegm, the prudent application thereof may be sometimes of service. We must also consider, that the lixivium of quick-lime has a great force in correcting, and extricating the muriatic, fixed salts in the blood, and fitting them to be easily discharged; whence it becomes an extraordinary remedy in that kind of scurvy, which chiefly proceeds from the above-mentioned causes: but in that kind which proceeds from putrefaction, and consists in a sharp oil and salt,

salt, it proves highly prejudicial. Whence, perhaps, we may in some measure reconcile the experiments of some eminent physicians in *France*, which shew the lixivium of quick-lime to be pernicious in that country; whereas in *Germany* it appears a very advantageous medicine. But all this holds truer of the quick-lime prepared from stone, than of that from shells: the particulars hence arising seem to be these; (1.) The violent corrosion, which happens in a live body, upon the application of quick-lime, proceeds more from those fiery saline spirits, which the lime produces from the salt that was not sharp before, than from the corrosive body of the lime itself. (2.) And hence it may be of use in diseases proceeding from acid, aqueous, austere, viscous, mucous, and phlegmy causes, where motion and stimulation are wanting. (3.) On the contrary, it proves hurtful in acute distempers proceeding from alkaline, bilious, saline, putrid, acrimonious, and heating causes; where the body is dry, and strongly agitated by motion. (4.) The mild salts of the body may instantaneously become extremely sharp and poisonous, by the bare admixture of a thing not sharp itself. (5.) That an exceeding sharp matter may be produced from healthy juices, which is neither a salt, spirit, nor oil; for this liquor cannot, by any art that I know of, be made to appear in the solid form of a salt, and can be only obtained invisible by means of water. (6.) These spirits, therefore, that do not appear to be alkaline by any experiments made with acids, are much sharper than any alkali; so that there is not any known thing that yields a sharper and more odorous vapour. Whence also it appears, how suddenly a very different taste and smell may arise from the salt of the body, which is almost inodorous.

P R O C E S S XCVIII.

The native salt of urine.

TAKE very fresh urine, discharged twelve hours after eating, by a man in health, and immediately, by a gentle fire of two hundred degrees, evaporate it in a clean vessel, till it acquires the consistence of cream. Then strain the liquor hot thro' a flannel bag, that the viscous oil may be somewhat kept back and separated, which the more exactly it is done, the better. Set a large quantity of this inspissated liquor, in a tall, cylindrical, glass vessel, tied over with paper, in a cool place, for a year; during which time, a saline, solid, hard, brown, and somewhat transparent mass will concrete to the bottom thereof; and a thick, black, unctuous liquor float above it, as separated and excluded from the salt. Pour off the liquor, and putting the saline mass into another vessel, add very cold water thereto, and shake it a little therein, to cleanse it from its oily foulness; which is easily done, because the matter does not readily dissolve in cold water. Let this saline mass be preserved under the title of the native salt of urine. If this salt be dissolved in water, and several times strained, till the solution becomes limpid, and then exhaled to a pellicule in a clean glass, and set to rest in a cool place, it shoots into saline glebes,

‘glebes, of its own peculiar kind, very different from any other salt, tho’ somewhat resembling the crystals of sugar, in figure and hardness. They are not fetid, or alkaline, but extremely volatile: and this is the purified salt of urine.’

The use.

This experiment excellently shews physicians the nature of those salts, which in an healthy body are very sharp, and greatly inclining to an alkaline nature, yet not really alkaline; and therefore require to be quickly discharged by the vital powers, to which they however owe their origin. And hence physicians may know that the other salts, contained in the other juices, are much less sharp or alkaline. These salts are generated in the human body alone, from the meat, drink, and sea-salt taken in and changed. There is sea-salt contained herein, but not alone. It is a saponaceous salt, but not very unctuous. It is highly diuretic, if drank diluted with water; and sudorific with a proper regimen. It has such extraordinary effects upon metals, that some have thence promised themselves wonders. All the fat matter, which remains upon straining, and cleansing the inspissated urine, is, when dried by a gentle fire, excellent for the producing of phosphorus; for which end it may be preserved. The experiment also shews that the salts remaining in the urine, thus inspissated, will not putrefy, or grow alkaline, so as to become volatile, and easily fly off, tho’ they are otherwise so easily changed. It should be considered what share this salt has in producing the stone of the bladder or kidneys.

P R O C E S S X C I X

Milk, by digestion, affords cream, and turns sour.

‘**S**ET new cow’s milk in a capacious, cylindrical, glass-veffel, in a cool place, barely covered with paper; there will soon be gathered on the top a white, thick, unctuous, mild liquor, called cream, which is neither acid, nor alkaline: let this be carefully separated and kept apart in another clean glass. In a short space, afterwards, more of the same, but less in quantity, rises, which is again to be taken off, and added to the former; and continue thus till no more cream rises. The remaining liquor is thin, somewhat transparent, and bluish. The cream is an excellent balsam for external and internal use, agreeable to the body, and allays all acrimony, so as to prove highly serviceable in cases of the pthisick, stone, or gout, and also serviceable, when applied to wounds and ulcers. The skimm’d milk is an incomparable remedy for sharp diseases, in fat and bilious constitutions, as containing no oil. Hence it appears to have a great relation with vegetable emulsions, made according to the twenty-first process, only differing on account of the juices it is mixed with, and the different degree of heat in the body. If the milk stand in a clear, pure, warm air, no way infected with fetid or putrid exhalations, or in sixty degrees of heat, or more, it soon begins to turn sour, and afterwards becomes perfectly
‘fectly

'fectly acid, so as at length the whole milk, together with its cream, manifest a considerable acidity by their smell, taste, acrimony, and other signs. In like manner the cream, carefully separated from the milk, also turns sour in an high degree; and then also affords an excellent balsam for external and internal use in hot and bilious disorders. And all this happens sooner in the heat of summer, than in the cold, and the more when the cow feeds upon grass, than upon hay; and the more when the creature is less exercised, than after having undergone violent motion. When the milk is afforded by an animal heated above measure, whether by labour, or otherwise, or was fed with animal food, or alcalescent vegetables, &c. or came from creatures under a burning fever, or a putrid disorder, the milk, treated in the manner above-mentioned, will be found of a somewhat fetid and urinous odour, of a yellowish colour, thin, and not of so sweet, but of a saline ungrateful taste; and thus it will not turn sour by digestion, but acquire the unpleasant odour of rancid cheese, and tend almost to an alkaline nature; whence such milk in nurses is abominated by the infants.

The use.

This experiment is of that kind, which, tho' simple, teaches many useful particulars, both to the chemist and physician. It shews that milk, more than any other juice of the body, abounds with oil; which here more easily separates from the aqueous part, than in any other; whence milk holds but little salt, and that not wrought in, and united with the oil, and therefore greatly differs from a soap, which is compounded of salt and oil united together: whence oil is slowly subdued, or thoroughly mixed with the other juices of the body. And hence it is that oil so often and so easily separates from the rest, and collects into the cells and cavities of the bones, destined for its reception; from whence again it may and usually is dissolved by heat and motion, so as to return into the veins, mix with a sharp saline matter, and at length be discharged the body under the form of strong-scented, fat, yellow sweat, or sharp, high-coloured, putrid urine. It is manifest also, that this oil of the vegetable milk long retains its disposition to acidity in the body, and there sometimes is converted into acid. And all milky aliment tending to acidity, whether it proceed from animal, or vegetable substances, does for some hours retain this disposition in the body, and operate upon it; but if the vital powers, great heat, the want of acidity, and the corruption of the air, act upon this cream or milk, it may then grow bitter, rancid, or alkaline, and forsake its acid nature, as we have formerly observed of tartar. We must therefore use great care, and cautiously distinguish in pronouncing upon the nature of juices in animals; for the milk deposited in the breasts may, by a fever, be changed to a rancid acrimony, and produce strange disorders, as we daily find. And the same thing may happen in the milk mixed with the blood. Certainly the oil of milk may grow acid, bitter, rancid, and at length putrefied; its cheesy part also may grow rancid, putrefied, highly acrimonious, and somewhat alkaline: its serous part usually grows chiefly acid, but seldom undergoes any other change.

PROCESS

PROCESS C.

Urine, by digestion, turn alkaline, and changes its colour, odour, taste, and virtues.

IF such urine as was described under the ninety-second process, be kept in an open vessel of glass, earth, wood, or metal, in an air of thirty-three degrees of warmth, it begins to smell fætid, putrefy, and change its straw-colour for a dusky brown; depositing gross fæces, and thus in a few days acquiring an alkaline lixivious nature, and at the same time striking a stony crust on all the sides of the vessel. The hotter the air is, the stronger and quicker this change of the urine is made; whence in the summer-time, especially when the weather is hot, all this happens in a greater degree. To discover how far this changeable nature would reach, I filled a bottle with natural recent urine, and corking it close, set it in a moderately warm place; and, after three months, I found it changed, in this close vessel, as is described in the preceding case. And herein the change principally consists; the recent urine of a man in health is of a straw-colour, but when thoroughly digested, of a colour betwixt brown and blackish; and from the degree of a straw-colour, it daily proceeds thro' successive changes, till at length it ends in a deep brown; and the more it is putrefied, the darker the colour. And the same thing is observed by physicians in the urine of persons under a fever; the state of the juices being learnt from the colour of the water. Recent urine smells ungrateful, tho' not alkaline; but digested urine has a manifestly fetid, volatile, alkaline odour, very different from the other. Recent urine is of a bitter, saline taste; but digested urine putrid, sharp, alkaline, and perfectly lixivious. Recent urine affords no signs of containing an alkali; but digested urine makes an ebullition, and a violent effervescence, upon mixing with any acid, and in every other trial, manifests a true alkaline nature. Recent urine has no saponaceous scouring virtue; but digested, putrefied urine is used by scourers and dyers, as a sharp lie, that cleanses foul wool, silk, &c. after the manner of fixed alcalies: and as these changes happen, with a small degree of heat in a close vessel, which every one may be easily satisfied of by trial, it is in vain for chemists to deny this property in urine.

The use.

We are here to consider, that there is separated from the body, by the urinary passages, a water containing salts and oils, approaching to a state of putrefaction; nor do we find, in all the body, another fluid that is so easily changed by such a digestion in close vessels. Urine, therefore, which is destined for excretion, cleanses the blood from these noxious, putrid matters; and, therefore, if retained thro' any distemper, it produces mortal effects, as being soon rendered sharper by the heat of the body, and thence presently intolerable to the finer vessels, and dissolving to the humours by a pernicious relaxation. And as it thus easily and suddenly acquires these new properties

perties in a close vessel, with a moderate heat, we are shewn that the body neither produces vinegar, nor inflammable spirit from what it takes in, and consequently does not act by fermentation, but introduces the true change of a putrefied substance, and therefore in its effect approaches nearer to the nature of the eighty-eighth process: for if bare stagnation can occasion this change of the urine, how greatly must it be disposed to a true putrefaction? And hence we see, how great necessity there is of water, acids, and saline matters in those persons who live in hot climates, and accustom themselves to daily labour and exercise; for by meats, drinks, and sauces of this kind, too great a tendency to putrefaction is prevented. Hence also the daily necessity of a mild, somewhat acid, and a new chyle, for sheathing the acrimony produced in the blood. Hence also it appears, that in twenty-four hours, the necessary utility and service of this new chyle vanishes; and that fresh assistance is likewise required from the same means. In burning fevers, therefore, tart, acid, and mild aliments, like chyle, are extremely necessary; great abstinence being in these cases highly prejudicial. And hence it is that barley ptisans, with vinegar and honey, are here so serviceable, as *Hippocrates* prudently inculcates, in his incomparable book concerning the diet in acute diseases. The physician also, upon examining the urine, by means of these experiments, may learn many useful particulars, with regard to the change of the oil and salt thereof; and perceive that a true stone may be generated from the urine of a man in health, even by rest, and whilst the urine putrefies, or grows alkaline; and therefore that attenuation, alcalies, and putrefaction, do not prevent the origin of the stone, since it may be generated, and not dissolved even in putrefied urine. Hence, therefore, as tartar is generated in the best wine, so is the stone generated, and not dissolved, in the urine elaborated by the vital powers: and, therefore, volatile alkaline salts are in vain given to prevent the generation of the stone. The following experiment I have seen with horror. Upon filling a clean glass bottle, with the recent urine of a healthy person, and setting it by for some time, then pouring out the putrefied liquor for distillation, there was a stony crust all round the inside of the glass; without washing this off, I filled it with fresh urine, set it by as before, and afterwards emptied it; and by repeating this several times, I at length found the whole surface of the glass perfectly crusted over with the matter of the stone. This production of a stony matter seems very destructive, tho' necessary to the body. It may, perhaps, seem strange, why the body should not therefore putrefy by its own vital heat and motion, since it so soon putrefies the wholesomest juices; and since dead carcases, exposed in air heated to eighty degrees, in a few hours putrefy, resolve away, and fly off into the air; leaving only the bones behind: but chemistry supplies us with this answer, that such a putrefaction is prevented by the meat, drink, sauces, air, and sometimes the medicines used, which resist putrefaction; otherwise, in burning fevers, the whole structure of the body would presently be dissolved by putrefaction.

PROCESS CI.

Digested urine affords, by distillation, an alkaline spirit, a fetid oil, a volatile, alkaline salt, phosphorus, and sea-salt.

TAKE urine, digested according to the foregoing process, distil it and with a gentle fire in a low glass body; there first arise veins of liquor running in the form of unctuous spirits. The receiver being changed, and the fire a little increased, there follow dewy drops, resembling water; and this water may be accurately separated till the matter remains almost dry; which, again being urged by degrees, and at length by a strong fire, will afford a yellow and very fetid oil, along with something saline; black fæces will remain behind, which, when burnt in an open fire, become a white calx, that with water resolves into sea-salt, and a fixed, insipid, subtile earth. The first water is fetid, sharp, fiery, perfectly alkaline, and makes a violent effervescence with acids. If this be distilled in a tall vessel, by a gentle fire, it affords a white, solid, truly alkaline salt; and leaves a water of an ungrateful smell and taste behind. When the water that came over second is long distilled in a tall vessel, with a gentle fire, it affords somewhat of the former spirit; which being carefully separated, and the remaining water distilled in a clean vessel, it affords a liquor which *Helmont* recommends, in his treatise on the stone, for an admirable lithontriptic. There here appears no fixed alkaline salt, but a true sea-salt, if the person used much thereof: but when I desire to obtain a large quantity of the salt, I usually proceed thus.

I put a hundred weight of urine into a large low vessel that widens upwards, and inspissate by boiling, with care to prevent the unctuous matter from boiling over; and being left, till the whole acquires the consistence of honey, I put a large quantity of this into an open cylindrical glass, and expose it for some months in a warm room, so that it may be well putrefied; I afterwards put the mass into an iron pot, to the mouth whereof a large earthen still-head may be commodiously fitted, and closely luted; the head has a long pipe, to which I apply a capacious receiver, then raise the fire by degrees, upon which an incredible quantity of a white alkaline salt arises, next a yellow oil that souls the former salt, and with it another salt somewhat more fixed. I urge the fire till the pot begins to grow red-hot, at which time the oil and the last salt come over; then suffering the iron pot to cool a little, whilst the fixed matter continues sufficiently hot, I take away the receiver, and put up all that was raised into glass bottles, and stop them close. This afterwards resolves into spirit, salt, and oil as the former. If what now remains at the bottom, be mixed with twice or thrice its weight of wood-coal, and then put into little coated retorts, and urged with the utmost violence of fire for sixteen hours, into receivers filled with water, and so placed as to bury the necks of the retorts under water, little blue masses of matter will at length come over, and fall to the bottom of the receivers, whence they are collected so as to be gathered together under

‘ water, in a small vessel ; which being set over the fire so as to be very
 ‘ hot, the matter of the phosphorus melts without dissolving in the hot
 ‘ water, and runs into one mass like melted wax, and may be afterwards
 ‘ preserved for twenty years, or more, under water, without losing its
 ‘ virtue (a). But if another part be taken of the mass, as it remains in the
 ‘ pot, and calcined in an open fire, to a white calx ; this calx, when put into
 ‘ water, communicates a saline matter thereto, and which, when reduced,
 ‘ proves to be true sea-salt, that remained thus unchanged thro’ all the di-
 ‘ gestions of the body, and even after such a long continued putrefaction
 ‘ and distillation. That it is a true sea-salt appears manifest from the taste,
 ‘ but more particularly, because, when mixed with *aqua fortis*, it dissolves
 ‘ gold : so that there is no fixed alkaline salt found even in this urine ; but
 ‘ whatever it contains of saline is either of the volatile kind, or sea-salt.’

The use.

This is the true analysis of urine after putrefaction, where it affords all the same matters as that which is distilled fresh, tho’ with a less heat, and in an inverted order. Putrefaction renders the salts more volatile than water, and makes those alkaline which were not alkaline before ; it renders the oil sharper, more fetid, and more volatile, yet produces no inflammable spirit, no fixed or volatile acid, nor any fixed alcali. Yet these two salts appear differently volatile, the first whereof easily rises and separates almost pure ; the other with more difficulty, slower, and mixed with a copious oil, not easily to be separated from it, and requires a large, and in part the strongest fire to raise it. I once urged the prepared fæces of urine, with the most violent fire, for the making of phosphorus, and was surprised to find how long this saline matter continued to come over, after having so long suffered the violence of a former fire ; but this salt was strangely dense, yellow, fetid, and fixed to the sides of the retort. All acids, therefore, are here changed into a neutral, saline substance, by the vital powers ; yet this neutral salt becomes truly alkaline by putrefaction, and more volatile than any hitherto known, even than alcohol itself. This putrefaction volatilizes all the saline matters of animals and vegetables, but can neither convert sea-salt into an alcali, or render it volatile. Some eminent chemists have said, that an acid might, by the force of fire, be drawn from the fæces of urine, remaining after its distillation : and I have found this true, where common salt was largely used by the person, and not changed, as was above observed, but remaining plentifully in the fæces : for being thus mixed in a large proportion of earth, the extreme violence of the fire drives over the acid of the salt, which has thus been hastily taken for the acid of the natural juices : yet it must be acknowledged that phosphorus spontaneously resolves into an acid by the air, not greatly differing from the oil, or acid spirits of vitriol or sulphur ; whence it makes a kind of compound body with

(a) See Boyle Abr. vol. III. p. 208. The A&L. Lips. 1683. p. 457. Homberg, Memoir. Math. & Phys. 1692. p. 74, and 80. Nieuwentyd, p. 520. Hoffman, Dissert. Phys. Chem. p. 336.

quicksilver (a) : but whence this acid should proceed, I am at a loss to know, as also of what nature it is. Certainly, it suits neither with animals or vegetables ; perhaps, alum might be added in the preparation : for thus it may be obtained to advantage ; and the acid spirit of alum is very like that of vitriol. On the other hand, it has appeared by experiments, that fowls feeding upon vegetables inclined to acidity, and drinking nothing but water, whilst they were cooped up, and being afterwards calcined with an open fire, together with all their excrement, afforded fæces that contained nothing either of acid, or of an alkaline nature. If a spirit, highly saturated with volatile alkaline salt, be highly rectified, it becomes limpid ; but if afterwards long kept, it changes brown, and generally deposite something terrestrial to the bottom and sides of the vessel. Let it be examined whether this is not that volatile earth, which rises with the first spirit of putrefied urine, that tarnishes the glass so as not to be got off again but by the other subsequent spirit, which, tho' scarcely saline, spontaneously dissolves it ; of which *Helmont* treats so largely in his noble book of the stone. This deserves to be thought of and tried, as being an easy thing that has its use. Certainly alcalies rather generate the stone ; but if the second liquor, which is not alkaline, dissolves the stone, then urine will contain both the matter of the stone, and its solvent. Sea-salt, therefore, does not generate the stone, but rather resolves it, and prevents it, as hindering, by its saltiness, the tendency of the humours to an alkaline nature and putrefaction. Whence *Helmont* conceives, that vinegar, sea-salt, and sulphur, were the great anti-pestilential remedies of *Hippocrates*, being used along with fumigated wine : whence the adepts declare, that nature has lodged absolute perfection in salt. It does not however commodiously dissolve the stone formed in the urine, or the concretions of the gout.

PROCESS CII.

The origin of sal-ammoniac.

THE present sal-ammoniac comes to us in merchant-ships, chiefly from *Egypt*. It is almost transparent in the middle, having long parallel shoots : it is black at the bottom, and formed into cakes, which are flat at the top, spherical below, and considerably dense and large ; the middle part, when examined pure, has scarce any odour ; it has the taste of sea-salt, but is much more penetrating : in the open air it soon spontaneously runs wholly into a clear, saline solution ; it is a salt like that I obtained from foot, as mentioned under the eighty-sixth process ; so that the two would scarce be distinguished. The present sal-ammoniac is made of ten parts of the inspissated urine of animals, chiefly of camels, which drink little, two parts of sea-salt, and one part of the best wood-foot ; all which they boil in water, strain and dry, then sublime in proper vessels ;

(a) See *Homburg, Memoir. de l'Acad. 1706. p. 340. & Mem. de Math. & Physic, 1692. p. 80.*

again

‘ again dissolve, purify and coagulate; and in both these ways this salt is obtained (a).’

The use.

The origin of sal-ammoniac is wonderful. The ancient *cyrenaical* or ammoniacal salt was made from the urine of camels, plentifully discharged in the sand, dried by the sun, and afterwards sublimed in the sandy deserts of *Lybia*, where camels are chiefly used. Such a salt Mr. *Tournefort* presented to *Pomet*, which differs greatly from our common salt (b); as seeming wholly animal. There is another sort, said to be at this time produced and collected in hot countries, near burning mountains, which seems to proceed from soot (c); and from soot I have myself made it. But the compound kind consists of an animal, vegetable, and mineral substance united together; for urine of itself putrefies into an alkaline salt; but sea-salt keeps this under, and curbs and turns it into sal-ammoniac: and the soot of burnt vegetables yields the same salt. It is no less wonderful in its virtue than its origin. If dissolved in water, strained, and inspissated to a pellicule, it affords white subtile crystals like dew; which being dried, and carefully preserved from all moisture, and afterwards mixed with water, cool it more in the instant of solution, than can be done by any other known means. It admirably preserves all animal substances from putrefaction; and its solution penetrates to the innermost parts thereof. It is chiefly opening, attenuating, dissolving, resolving, sternutatory, diaphoretic, sudorific, diuretic, and preservative.

PROCESS CIII.

Sal-ammoniac is neither acid nor alkaline.

‘ **D**ISSOLVE pure sal-ammoniac in thrice its weight of fair water, filter the solution, heat it to a hundred degrees in a clean glass, and pour thereto, successively, vinegar, spirit of nitre, and spirit of sea-salt; there thus arises no sign of effervescence, nor is the liquor so much as troubled; whence it appears that this salt is not alkaline upon these trials. Indeed, when oil of vitriol is poured to it, there arises a certain fume and motion; but this is owing to another property of the salt, which will be more commodiously explained hereafter, under the hundred and sixth, and hundred and seventh, but particularly the hundred and forty-third process; whilst the oil of vitriol lays hold of the alkali of this salt, and renders its acid spirit, which is the spirit of sea-salt, volatile. To another quantity of the same solution add fixed alkali, and this also causes no effervescence; but there immediately rises a very pungent, volatile odour. Hence it appears, that sal-ammoniac is neither acid nor alkaline.’

(a) See *Olaus Worm*, Mus. p. 20. and *Cæsius de Fossilibus*.

(b) See *Pomet* of drugs, and compare *Pliny* 31. 7. and *Dioscorid*.

(c) *Hist. de l'Acad.* 1705.

The use.

Sal-ammoniac, therefore, agrees with the natural salt of the body, which neither makes an effervescence with acids nor alkalies; but when mixed with fixed alkali, immediately sends out a volatile part, with a very pungent odour: and that it does not act either in the body, or elsewhere, by an acid or alkaline virtue, but by that of common salt rendered more penetrating, appears from all its effects, especially from hence, that when sal-ammoniac is mixed with spirit of nitre, or *aqua fortis*, it immediately gives them the power of dissolving gold, or turns them into *aqua regia*, which nothing but common salt can do; and therefore in this sense sal-ammoniac is a half volatile sea-salt.

PROCESS CIV.

Sal-ammoniac sublimed into flowers.

REDUCE sal-ammoniac to fine powder, dry it thoroughly, put a pound thereof into an almost cylindrical *Haffan* body, fit on a very capacious head, lute the juncture with equal parts of clay and sand wrought together; set it in a sand-furnace, so that the pipe of the alembic-head may stoop a little, in order to discharge the water, that may happen at first to come over into the receiver, then bury the body in sand almost up to the lower rim of the head; give a fire first of a hundred and fifty degrees, till all the moisture is raised, and come into the receiver; which being now changed, raise the fire so long by degrees, till the glass-head begins to be darkened with a kind of snowy matter, and continue the same degree of heat for eight or ten hours without slackening; now let all cool, take away the sand, and carefully remove the body with its head, without shaking, for fear the salt, raised into the head, should fall out. Then place them both horizontally upon a table, and with a knife take off the luting; and whilst both the body and head remain in this position, gently wipe away the dust, sand, and remains of the luting; the head, now separated, will be found full of a light, snow-white salt, sublimed by the operation. Take all the salt out, and put it into a dry, hot, wide-mouth'd glass. There will also be found towards the upper part of the earthen body, a white, thick, dense and compact crust of the same salt, that here remains fixed, without rising into the head; this, being separated with a knife, is to be put into another glass apart: then gently invert the body upon a clean paper, and there will fall out a large quantity of the former snowy flowers, made to fall back by the motion of the vessels. If these are perfectly pure, they may be added to the former. At the bottom of the body there remain a small quantity of black, saline, feculent matter, of no great use, which may be got out by shaking the vessel; it is bitter, black, and foul. The former part, being kept separate, is called the flowers of sal-ammoniac, or the white eagle of the philosophers, that carries *Ganimede* up to *Jove*: the other salt, which stuck to the other part

of the body, is a sublimed sal-ammoniac. If the flowers, or sublimed salt, be dissolved in water, they produce coldness, as we above observed. If any acids be mixed with the heated solution, no effervescence arises, except with oil of vitriol, as was observed of the salt in the preceding process. It makes no effervescence with fixed alkali, yet immediately raises the same vapour as was before described; but when the sublimation of the sal-ammoniac is often repeated, it gradually begins to rise with more difficulty, and at length becomes almost fixed, tho' it still retains its former nature.

The use.

This salt is of the nature of sea-salt, and half volatile; for tho' it will not ascend with the heat of boiling water, yet it is not so fixed as sea-salt. When thus purified, it loses the transparency, which is in some measure found in common sal-ammoniac. This salt does not grow alkaline by sublimation; in which respect it differs from the salt of urine, as still remaining what it was, tho' more purified. It has this wonderful property, that by thus rising dry in a close vessel, it carries up with it almost all animal, vegetable, and mineral substances, and strangely subtilizes them in the sublimation; whence it has been called the pestle of the chemists; as those bodies could scarce be so subtilized by any other means. But if often sublimed with sal-ammoniac, they are thus at length fixed therewith; and in this method excellent medicines are often prepared; as we see by the example of *Paracelsus* in colcothar well washed in water, then ground with sulphur, and sublimed with this salt.

PROCESS CV.

Sal-ammoniac, with quick-lime, affords a fiery spirit, like that of the ninety-seventh process.

1. **P**UT well dried flowers of sal-ammoniac into a glass-body made hot, pour thereon an equal quantity of quick-lime, suddenly reduced to fine powder, in a hot and dry iron mortar, so that the flowers of sal-ammoniac may be well covered therewith. Immediately clap on a dry alembic-head to prevent all evaporation; for at the instant these two bodies touch each other, tho' they were before at rest and inodorous, there arises, perhaps, the most pungent and violent vapour hitherto known. In these two respects it certainly far exceeds the spirit obtained, by the same means, from urine, in the ninety-seventh process. After the head, therefore, is well luted on, distil, with a sand-heat, into a proper receiver; a very small quantity of liquor will thus be obtained, but it is the most volatile and sharp of all that are known, yet not alkaline. And now if the fire be urged, the sal-ammoniac does not sublime, but remains fixed in with the quick-lime; and if put into a crucible, and melted with a very strong fire, it still remains fixed, and when cooled and well dried, it thus affords a light like phosphorus, if broke in the dark (a).

(a) See *Hist. Acad. Royal. du Hamel*. p. 305, 306, 307, 408.

2. Reduce

2. Reduce pure sal-ammoniac to powder, dissolve it in thrice its quantity of fair water; then put into a large glass-body, a little heated, thrice the quantity of quick-lime, in respect of the sal-ammoniac; pour the solution thereto, instantly clap on the head, directly lute with a thick luting of linseed-meal, and apply a very capacious receiver, joined with the same luting; a heat and violent ebullition will now suddenly begin to rise, yielding a spirit so forcible as to burst the vessels, if the luting was not to give way, thro' which the spirit flows like blasts of wind, and diffuses an odour all round; at the same time there suddenly comes over a large quantity of liquor into the receiver. As soon as the spontaneous heat of the mixture ceases, lute the junctures stronger, apply a little fire, and gradually distil to dryness. Let the spirit that comes over be directly put up in a glass to be close-stopped, and kept under the title of the spirit of sal-ammoniac with quick-lime.

3. There now remains at the bottom a strange and new kind of body, which when dried at a strong fire, appears somewhat glassy; but it gradually swells in the air, tho' it does not run like sal-ammoniac, but resolves into sandy grains, as the excellent Mr. *Homburg* has observed (a).

The use.

We have hence a new agreement betwixt the proper salt of the human body, and sal-ammoniac; here is a liquor produced from dry bodies; a highly odorous matter from what was inodorous, and affecting the organs more strongly than any other known thing. We here see spirits produced, which are extremely moveable, as it were spontaneously, in the highest degree of cold; and these spirits, tho' exceeding sharp, and almost as acrimonious as fire, yet are not alkaline. This spirit, however, floating thro' the air, and meeting with the volatile spirit of nitre, affords white fumes. We have here a new species of phosphorus, and an instance of sal-ammoniac rendered in some measure fixed.

PROCESS CVI.

Sal-ammoniac, distilled with fixed alkali, affords an alkaline spirit, and a volatile alkaline salt.

1. **P**UT ten ounces of the dry flowers of sal-ammoniac into a glass retort, add thereto three ounces of dry salt of tartar, reduced to powder, shake and mix them well together; there immediately arises an extremely sharp and alkaline vapour; therefore, instantly apply a large glass receiver, and sublime in a sand-furnace by degrees, giving at length a violent fire. A white, pure, volatile, alkaline salt will thus rise, which soon spontaneously flies away into the open air, from the vessel it is contained in, and nearly thro' all stoppers, except those of glass: it makes a violent effervescence with all acids, and concretes with them into a neutral salt, according to the nature of the acid: it can scarce be employed, or con-

(a) *Hist. Academ. Roy. du Hamel.* p. 305, 306, 307.

‘ fined, on account of its extreme volatility ; and is difficult to take out of the receiver in this solid form. A fixed salt remains at the bottom of the retort, which cannot be sublimed by the strongest fire.

‘ 2. Or to the same flowers add three ounces of the salt of tartar, and nine ounces of water ; mix them, and distil into a receiver exactly luted on, with various degrees of fire. A moist, flatulent vapour will presently rise, which directly congeals on the sides of the receiver into a solid salt, and continues to do this every moment, till the chief part of this salt being come over, it begins to resolve by the rising of a less volatile and more aqueous liquor. Therefore, change the receiver, and urge the fire till the salt remains dry at the bottom, then by well shaking the former receiver, mix the salt with the liquor, till it breaks, and becomes almost dissolved ; then pour it into a clean glass, the mouth whereof is exactly fitted with a glass-stopper. A salt will fall to the bottom, and a fluid liquor float above, which is a true and strong volatile, alkaline spirit ; but when no alkaline salt remains in a solid form under the liquor, the spirit is not rich, but aqueous, and unfit for many experiments. At the bottom of the retort there remains a fixed salt, exactly like that in the preceding process.’

The use.

The sal-ammoniac, in this operation, is by its own nature, and by means of fire, divided into two very different saline parts, immediately upon touching fixed alkali. The first of these parts we shall here consider, and the second in the following process. The first, therefore, constitutes an extremely sharp, alkaline, fiery, volatile, pure salt, as any that can possibly be obtained by art, and at the same time the most simple ; so as to be held for the standard of volatile alkali, under which the other kinds may be reduced, and accordingly distinguished. The true alkaline spirit of sal-ammoniac is therefore a water, impregnated with as much pure alkaline salt, as it can dissolve, and with this likewise all the other alkaline volatile spirits may be compared ; and, indeed, all other volatile alkaline salts and spirits are never so pure and genuine as these, but constantly infected by some oil, which occasions them to act very differently ; but in this property also sal-ammoniac agrees with the salt of urine, as appears by the ninety-sixth process ; for the present salt and spirit instantly make a violent effervescence with all acids. If the glass, containing either this salt or spirit, stand open near another filled with the strong acid spirit of nitre, there immediately arises a considerable effervescence in the air, proceeding from the volatile acid and alkali meeting therein. If this salt be applied to the warm skin, and kept close to it by a plaister, to prevent its exhaling, it presently burns the part with intolerable pain, and with a violent inflammation turns it to a black gangrene, so that there is scarce a more sudden poison. Whence it should seem imprudent to direct the use of these salts or spirits in the way of smelling-bottles, for fear of corroding and inflaming the olfactory nerves, the membrane that lines the nostrils, and the tender vesicles of the lungs. Both this salt and spirit are tendered still more fiery by subliming them afresh from pure, dry, fixed alkali.

PROCESS

PROCESS CVII.

The fixed salt remaining in the preceding process, examined.

TO the salt remaining at the bottom of the retort, in the preceding process, pour as much warm rain water as may wholly dissolve it, then filter the liquor, inspissate it, and reduce it to crystals, till almost the whole quantity is thus prepared: by this means there will be obtained a salt, which in its taste, its cubical crystals, and power of dissolving, resembles common salt; and if put into a covered crucible, and decrepitated, and calcined for some time, then dissolved and coagulated, a pure salt will be obtained, which taken in the quantity of a drachm, two hours before the fit of an intermittent is expected, (the body at the same time being kept warm) often cures the fever. Whence it is called the febrifuge salt of Sylvius.

The use.

This is the other saline and fixed part of the preceding process, arising from a mixture of fixed alcali and sal-ammoniac, agitated by the fire; it is neither acid, nor alkaline, but a compound neutral salt, tho' not ammoniacal, but fixed. Sal-ammoniac is made from the volatile alcali of urine, the volatile vegetable alcali of foot, and of sea-salt; so that here the fixed alcali, being strongly attractive of acid, draws to itself the acid of the sea-salt, and separates it from the volatile, animal alcali or that of foot. Whence the acid of the salt returns with the fixed alcali into a fixed sea-salt; and the volatile alcali of the sal-ammoniac, now set free from its fixed salt, becomes perfectly volatile, and when collected together, affords a pure alcali; and when saturated with the acid spirit of sea-salt, it makes regenerated sal-ammoniac, as will appear in the hundred and forty-seventh process.

PROCESS CVIII.

A saline spirit produced by mixing the strongest volatile alkaline salt, or pure alkaline spirit, with the strongest spirit of vinegar.

TO a quantity of pure volatile, alkaline salt, or spirit, contained in a large glass, pour at several times a proportion of the strongest spirit of vinegar, shake and mix them well together, till no more effervescence arises; warm the whole, then add more of the salt or spirit, and if now no farther ebullition appears, the point of saturation is obtained: and if the operation be rightly performed, the liquor prepared by this mixture of a volatile alcali, and acid, will be saline, tho' not easily reducible to a solid salt, but affording a very penetrating medicine.

The use.

This liquor is not only the most penetrating of all those applied to the body, but has its effect without any corrosion, and at the same time, by its preservative saline virtue, admirably prevents the putrefaction of the juices; so that, perhaps, a more noble aperitive, attenuating, diaphoretic, diuretic, and sudorific remedy is not known. When externally applied, in the way of fomentation, it is highly discutient and resolvent, and eminently serviceable in all diseases of the eyes, where any darkness appears in the *cornea*, or aqueous humour of the eye, being properly applied as a collyrium. Perhaps, this is the most subtle of all compound neutral salts, and may not improperly be called ammoniac.

PROCESS CIX.

The white of new laid eggs shewn to be neither acid, alkaline, nor spirituous.

‘PUT the whites of several eggs, carefully separated from the yolks, shells, and films, into different glasses, and to each of them drop different acids; shake and mix them; no sign of ebullition will appear. Set these glasses aside, and in two others put two fresh portions of white, and intimately mix with one a fixed alkaline salt; and with the other, a volatile alkaline salt; they will neither afford any sign of effervescence: but if half an ounce of the white of egg be contained in a tall cylindrical vessel, along with two drachms of the spirit of nitre; and in another vessel, half an ounce of white of egg, with four drachms of oil of tartar *per deliquium*, both of them heated to ninety-two degrees; and the white with the alcali be once poured into that with the acid, there rises a violent ebullition and rarefaction, tho’ almost without changing colour; and when the effervescence is over, they immediately shrink into the narrow space they possessed before. But if the recent white of egg be distilled with a fire of a hundred degrees, it affords only an insipid water, that contains no inflammable spirit. If the white be applied to the naked eye or a naked nerve, it excites not the least sensation of pain; it has scarce any smell, or taste, and to the touch appears viscous, and no way piercing.’

The use.

Hence there is no alcali, or acid, or a mixture of the two contained in recent white of eggs; and tho’ it appears so unactive a thing, yet it is a truly animal liquor, that with ninety-three degrees of heat, in the space of one and twenty days, gives growth to the chick in the egg, from a little speck, scarce weighing the hundredth part of a grain, into a perfect animal body weighing an ounce, or more. Hence we know that this liquor is different from all others; as by the requisite causes there may be produced from it fibres, membranes, vessels, *viscera*, muscles, bones, cartilages, tendons, ligaments, beaks, claws, feathers, and all the juices contained in the vessels;

vessels; and yet this fluid is mild, sluggish, without acid, without alkali, without spirit, and without any requisite for making an effervescence. Indeed, if there was the least effervescence therein, the egg would directly burst. Such, therefore, is the matter of the whole structure of the chick; which shews us from what a viscous and inactive substance, all the solid and fluid parts of its body is formed: yet this very matter is rendered unfit for producing a chick with a greater degree of heat. It can scarce endure a hundred degrees to advantage; and with a much less heat it would never produce a chick; for less than forty degrees will not suffice for that purpose; but with a middle heat, directed betwixt eighty and a hundred degrees, the wonderful viscosity of this substance is attenuated, so as in great measure to exhale thro' the shell, and its two membranes; whilst the yolk, the specks, and nutrimental bag remain behind: for the yolk is the placenta of the chick, and not consumed in the nourishment thereof. But *Malpighi* has shewn that this white is not of the same fluid nature throughout, as the serum of the blood is, whilst flowing thro' the vessels, but a compound structure of numerous membranous bags, filled and extended with their proper liquor, almost in the same manner as we see in the vitreous humour of the eye: and hence seem to proceed those waves concentrical to the little nutrimental bag, by means whereof the nutritious juice is gradually attenuated, and strained into the *amnion* of the chick.

PROCESS CX.

The white of egg hardened into a solid mass, by the heat of boiling water.

1. **T**HE white of an entire egg, being kept in a warmth of eighty degrees, soon loses its tenacity and thickness, and becomes so subtle, as to perspire at the obtuse end of the egg, thro' the skins there placed, so as to depress and separate them from the hollow part of the shell towards the yolk, and thus leave a considerable cavity. The remaining part of the white is dissolved, becomes thin and ichorous, and no longer hardens with the heat of boiling water, but becomes fetid, putrid, highly sharp, and destructive to the vital structure of the chick. 2. The recent white, being put into water, heated to a hundred and fifty degrees, loses its transparency, becomes white, opaque, and hardens into a dense mass, that may be cut with the knife; and if a little of this white be dropped into boiling water, contained in a glass urinal, it is presently coagulated, amidst the motion of the boiling water. In like manner, a whole egg is also coagulated. Whence it appears, that this coagulation does not happen thro' a loss of the fluid parts dissipated by the heat, but by the true action of the fire applied in such a degree; because this happens even in the midst of water; and if some of the white were to be mixed in with cold water, it would immediately come together, and separate from the water, upon boiling. 3. When the white is boiled hard in a whole egg, then taken from the shell, and separated from the skins, the speck, the yolk,

The Practice of CHEMISTRY.

‘yolk, and the nutrimental bag, and put into a glazed dish, it gradually begins, as it were, to sweat, and to resolve into a subtil fluid, which appears aqueous, yet is a very penetrating menstruum that excellently dissolves myrrh, and other bodies hard of solution.

The use.

This experiment shews us the heat required in that matter whereof all the parts of an animal may soon be formed; and we see that it dissolves with one certain degree of heat, but coagulates with a greater: and again, that a less dissolves it after coagulation. The whole, therefore, is owing to a determined degree of heat, without which nothing can here proceed well. And it will again appear, under the hundred and twelfth process, that a greater heat than of two hundred and twenty-four degrees will dissolve and attenuate what was coagulated by a heat of two hundred and twelve degrees. Hence, therefore, we are admonished to pronounce with caution, concerning the dissolving and coagulating power of heat, with respect to the nutrimental juices of animal bodies; or as to that heat, which may thin them, putrefy, inspissate, or resolve them into their parts.

PROCESS CXI.

The white of eggs examined with alcohol.

‘**P**UT the yolk of an egg into a glass, and gently pour thereto a quantity of alcohol, so that it may run down the sides of the vessel to come at the white; this should purposely be done to shew that the surface thereof immediately coagulates upon touching the alcohol, whilst the lower part still remains fluid and transparent. Then the two being gently shook together, it will appear, that wherever the alcohol touches the white, the white will there be coagulated; and when they are entirely mixed together, the whole white will thus be concreted. If the alcohol be previously heated, the effect will the sooner be obtained, as also the more briskly they are mixed together; for heat and motion increase this coagulation.

The use.

Hence again, it appears, that pure, inflammable, vegetable spirits will immediately coagulate the nutrimental matter of the chick, and instantly render it unfit to perform its offices. This addition of alcohol, however, prevents the white from putrefying; and hence we see how greatly the nutrimental matter of animals tends to coagulation; and what unexpected properties may attend too great a purification of certain things. Wine will mix with the white of egg; but the alcohol, afforded by wine, coagulates therewith, tho’ not if largely diluted with water.

PROCESS

PROCESS CXII.

The recent white of eggs analysed by distillation.

1. **BOIL** whole eggs in water till they become hard, then separate their whites, and chop them small; put them into a glass-body fitted with a proper head and receiver, set the whole body in a water-bath, and work with successive degrees of fire, so as at length to make the water boil strongly; there appear no veins, like those of spirits, but only a simple water like dewy drops, and of this there is an incredible quantity, even above nine tenths. Continue working thus till no more liquor will rise with the heat of boiling water; the liquor, so obtained, manifests no sign of oil, salt, or spirit; it is pellucid and insipid, excepting that it proves somewhat bitter towards the end; it is almost scentless, only a little empyreumatical at last: however examined, it affords no signs of its being either alkaline or acid: I have collected several pints of this water. There remains at the bottom of the body a very little quantity of matter, in proportion to the former; being only some little fragments shrunk to a very small compass. These are of a very yellow colour, especially where they touched the glass, and yet transparent almost like coloured glass. When they are taken out, they prove light, hard, perfectly brittle, and snap with noise; they smell somewhat empyreumatical, and taste a little bitter, on account of the fire; but are neither acid nor alkaline: and this is the first analysis.

2. Put these remaining fragments into a glass retort, so that two thirds thereof may remain empty; set the retort in a sand-furnace, lute on a capacious receiver, lute the juncture, and distil with degrees of fire, ending with the fire of suppression. There rises an oily spirit, that runs with veins, and at the same time a volatile salt sticks, in a solid form, to all the sides of the receiver: the quantity of this salt is large in proportion to the dry fragments, but small in proportion to the original white. At last there ascends a black, gross, and pitchy oil, besides the lighter gold-coloured one, mixed with the former matters; when this is brought over with the utmost force of fire, the earth remaining in the bottom, closely united with its highly tenacious oil, rarifies and swells up to the neck of the retort; and if the retort were too full, often comes into the neck, blocks it up, and sometimes bursts it in a dangerous manner. The operation must be continued till nothing more comes over. The first spirit is oily, and in every respect strongly alkaline; as appears by the violent effervescence it makes with acids: it resolves by rectification into a volatile, alkaline salt and oil, and a fetid, indolent water. The last oil is sharp, caustic, and highly fetid; the black earth, remaining in the retort, is shining, light, porous, and brittle, being also empyreumatic and bitter, on account of the last oil; if it be burnt in an open fire, it affords a little white, insipid, inodorous fixed earth, that makes a very fine powder, but yields scarce any salt by elixation.

The

LIXO *The use.*

The white of eggs, therefore, copiously abounds with water, but contains no alkali, that can be raised with two hundred and twelve degrees of heat; so that the matter, which with a stronger fire turns into volatile alkali, is not by this less degree disposed either to volatility, or an alkaline nature, and therefore contains no volatile salt; because we call that volatile salt in chemistry, which is more volatile than water, and rises with a much less degree of heat. It contains no inflammable spirit, which can be raised by the heat of boiling water; it contains no oil which can be separated by this degree of heat. Even the remainder, when the water is separated, is still so little changed by so great a force of fire, as to manifest no salt; whence with such a heat, the fluid part being driven off, it spontaneously acquires the form of brittle glass. Hence we understand, that the volatile salt obtained from the white of egg, is not a natural, but created substance; for after this volatile salt is separated from the remaining matter, by the fire, it is volatile with sixty degrees of heat; tho' it could not be obtained before therefrom, by three hundred. Whence this volatility is not natural to the salt of the white, but produced by the fire: and the same seems true of its alkaline disposition. Hence also we learn, that the oil adheres tenaciously to the more fixed part of the white; that the water is easily separated from it; but that the animal coal will never let go its oil in a close vessel, or without the assistance of the open air. These are the notions we ought to have concerning the white of eggs, from whence all things afterwards proceed. Certainly these particulars are very different from what is usually delivered of the chemical principles drawn from animal subjects. But what idea we should form of the saline matter pre-existing in the white of the egg, before it is committed to distillation, I know not; as being no way manifest to the senses. Thus much we are sure of, that from this indolent, insipid, and tenacious matter, the action of the fire alone may soon produce sharp, fiery and caustic matters, both saline, alkaline, and oily. But upon mixing all these together again, they will not recombine the same mild and viscous matter: and the natural heat, without a previous putrefaction, does not generate alkali in the body.

PROCESS CXIII.

Recent white of eggs putrefied.

IF sound eggs, or their whites, be kept in seventy degrees of heat, or more, they in a few days begin to resolve, grow thin, fetid, and putrefy: as also, if the eggs are whole, to grow empty at their obtuse end; and if now boiled in water, they do not grow hard, but remain fluid; and this change happens much sooner in eggs laid with, than without the assistance of the cock: in the latter kind, the greatest part of the corrupted moisture would exhale, whence the whole shell is at length almost filled only with wind or air. If an egg, or the white, be kept longer in

in this degree of heat, at length almost all its parts will strangely putrefy, turn alkaline, make an effervescence with acids, afford an alkaline spirit, and an alkaline salt for the first thing in distillation, perfectly like putrefied urine, as we saw in the hundredth process. But the white, thus putrefied, becomes almost totally volatile in the open air, and exhales as it putrefies; leaving at length scarce any thing more than a few thin skins behind: but no acid is ever here produced.

The use.

A small quantity of an egg, putrefied till it acquires this alkaline nature, has strange effects, if received into an healthy body; as there creating reachings, vomiting, anxiety, shivering, a looseness, gripings, heat, inflammation of the bile, a fever, and thirst. And merely by its putrid exhalation it occasions shiverings, reachings, and dizziness; and strangely dissolves down the juices of the body, like a pestilential poison. And this, we see, is the nature of that matter which is immediately changeable into the form and substance of all the parts of an animal body: rest, and such a degree of heat produce these alterations. And hence we see the spontaneous tendency of this matter to corruption and change; yet what seems highly wonderful, a prolific egg kept in a stove-room, heated to ninety-two degrees, distributes the parts, so attenuated and altered by that heat, in nourishing, augmenting, and perfecting the chick, in one and twenty days; and yet this chick contains nothing alkaline, fetid, or putrid. Physicians may here observe a wonderful change of things by such a heat, and rest; what was thick becomes thin; what was tenacious resolves; what was inodorous becomes fetid; what was insipid becomes nauseous, and of an abominably corrupted taste; what was mild becomes caustic; what was neutral becomes alkaline; and the sweet latent oil becomes highly putrefied and loathsome. Let these particulars be compared with those observed by *Malpighi*, in his treatise *de ovo incubato*, and they will be found surprising. I have endeavoured to perform these experiments chiefly upon the white of eggs, separated from the other parts, because the white is the only matter destined to feed the chick; the rest only serving to change this, and distribute it for the perfecting of the chick.

PROCESS CXIV.

Recent serum of human blood, shewn to be neither acid nor alkaline.

1. **W**HEN blood is drawn from a wide orifice, made in the vein of an healthy person, before eating in the morning, into a clean vessel, and suffered directly to rest, it soon separates into two parts, viz. a solid concreted cake, and a yellow thin liquid serum, which continually increases upon the same mass, if suffered to rest long. Separate this serum as carefully as possible from all the red part, and put it into a clean vessel. If the strongest vinegar be added to one portion hereof, no effervescence arises; add spirit of salt to a second, spirit of nitre to a third, and

‘ oil of vitriol to a fourth; and in none of these cases will any signs of effervescence appear.

‘ 2. In two other vessels put two portions of the same serum, and with one of them mix fixed alcali, with the other the volatile kind, and thus also they make no conflict, nor give any sign of a saline effervescence.

‘ 3. If now the serum, mixed with fixed alcali, be poured to that mixed with spirit of salt, a violent effervescence presently arises, so as to make the whole possess above ten times the space it occupied before; thus occasioning a much greater ebullition than that of milk over the fire, and this even in the cold.

‘ 4. This serum has a mild but latent saline taste, an ungrateful odour, but no way sharp or brisk; if a drop of it be let fall warm into the eye, it gives no pain, but is reckoned an immediate asswager in inflammations and wounds of the eyes; and when applied to the nerves, laid bare by wounds or ulcers, it is scarce felt.’

The use.

1. I have frequently observed the blood of healthy persons, as it has run from the vein in bleeding, started from the arteries in wounds, flowing from the nose in hæmorrhages, coughed up from the lungs upon the bursting of an artery; and again in dogs, sheep, oxen, and other creatures, upon being wounded or killed. I have also observed the blood rushing violently from the veins of persons that were blooded in burning fevers, phrenies, or the like; but upon examining it carefully, at the very instant it was received into a vessel, from the living body, I never found the least sign of any ebullition, effervescence, fermentation, intestine motion, or rarefaction; tho’ it was a little before violently agitated by so rapid a motion in the vessels of the body. Upon making these experiments, with care, some years ago, I at length changed the opinion I had imbibed from the reading of chemical books, especially those of *Sylvius*; for I certainly found that the senses could not discover any acid or alkaline principles in the blood; so as that these should be able to produce visible effects upon their mixture; such as ebullitions, effervescences, fermentation, intestine motions, or rarefactions; and hence concluded that they are not in the body; because, otherwise, they must appear at the instant the blood is discharged. If it be said they are there, but in so mild and gentle a manner as not to appear, I only ask how this can be proved. Certainly, thus much is plain, that if these opposite chemical salts do reside in the blood after such an indolent manner, they must be so weak as to produce no sensible effect, and therefore it is not safe to explain any sensible effect by supposing them.

2. The blood of a healthy person, left to itself, may be rather esteemed a solid than a fluid; and yet the solid thence produced again spontaneously resolves into a liquid: this is a strange thing but certain. If drawn upon an empty stomach, it separates spontaneously, not as milk into cream, and a more wheyish part, but into a concretion mass, and a liquor: the liquor of itself is yellow, and the red concretion mass purple, where it touches the air, but black in the middle of the mass, where the air cannot penetrate; but

but it gradually loses its redness in the air, and grows yellow, like the serum. There is no acid nor alkali found either in the serum, or any other part, that when mixed with its supposed opposite shews any signs of effervescence; but they rest as quietly together in this respect, as water does with water.

3. Hence it appears the disposition of the human blood is such, that if acid and alkaline salts were at once to meet in it, they would instantly cause such an expansion, that the rarified mass would swell into at least ten times its former space, and immediately after this sudden expansion ceased, fall down again, and return to the former bulk: which is an operation absolutely repugnant to the nature of the body, and the uniform continuance of health and life.

4. This serum contains all the matter which circulates thro' the vessels of the body, except the red part, and therefore holds whatever afterwards arrives at any vessel, whether great or small; that is, contains the nutrimental matter for supplying all the parts requiring growth, or repair; and consequently, the matter of the whole body, both solid and fluid. Hence appears the excellent use of this experiment in all cases relating to the body; and thus we hope, that chemistry may rectify those errors wherewith it had infected physic and philosophy. This serum is mild, indolent, and forms all the parts of the body, exactly like the white of eggs; for as all the parts of a chick proceed from the white of the egg, so do all the parts of the human body proceed from the serum.

PROCESS CXV.

The serum of the blood putrefied by digestion.

IF the serum of the blood be set in a tall open glass, with a heat of seventy degrees, it will soon begin to grow thin, and continue to do so every hour, so as in three or four days to become liquid, and sanious, fetid and cadaverous; and instead of the insipid and almost scentless thing it was, to acquire a rancid, sharp, and abominably corrupt taste and smell. And if kept thus a few days longer, it becomes alkaline, putrid, intolerable to the senses, and manifests an acquired alkaline nature, by making an effervescence with acids. If it be now distilled, it affords a volatile, alkaline salt for the first thing, exactly as the white of eggs treated in the same manner, according to the hundred and thirteenth process.

The use.

The serum, therefore, as examined by the senses, grows spontaneously thinner by rest, and a determinate heat; and, therefore, when stagnating in the obstructed vessels of an unhealthy person, it often spontaneously resolves with a gentle warmth and time, so as to open the parts that were before obstructed. Hence in acute inflammatory distempers, if the heat of the body be reduced to mediocrity, the fluids, that were coagulated, may be rendered fluid again, in a certain number of days, as we often find in the practice

tice of physick. The serum never turns acid by the change it undergoes in this experiment, whatever some eminent artists may have wrote to the contrary, but always putrefies without suffering any other change: no signs of fermentation here ever appear, even tho' all the means for promoting it were used, but only a determinate putrefaction. It is true, that putrefied bodies rarify and produce elastic fugitive air, but not the fermenting spirituous kind. Neither are inflammable spirits generated in this putrefaction, as by fermentation, but others of a putrid volatile kind, tho' indeed inflammable; for the fæces detained in a jakes that has no vent, so as to be strongly compressed, conceive a violent intestine motion, and discharge very fetid exhalations, which have caught flame upon the approach of a candle. And hence it sometimes happens that heat and rarification are excited in the human carcass; but this is chiefly about the *abdomen*, and not very great. And hence physicians may learn how the juices of the body will spontaneously degenerate, when extravasated, or obstructed. Lastly, this putrefaction is hindered by means of acid, compound-saline, and spirituous liquors.

P R O C E S S CXVI.

The serum of the blood coagulated in boiling water.

LET serum fall into boiling water; it presently turns white, and appears coagulated therein: in which respect it again agrees with the white of egg, as in the hundred and tenth process; tho' the white of egg coagulates stronger in the water than the serum.

The use.

Hence we see the effect of heat upon the serum of the blood; and the action of boiling water upon the juices of the body, when it comes in contact with the live parts, so as to scald them: and hence also it appears, that neither the saline nor oily part of the blood is rendered volatile by this heat.

P R O C E S S CXVII.

The serum of the blood coagulated with a dry heat.

PUT serum into a clean vessel, and gradually heat it over the fire; when it begins to fume, the part that touches the vessel begins to turn opake, white, and to coagulate, till in a short time the whole serum (but the middle part on the top last) concretes into a white, tenacious, opake, horny matter, waved on the middle, at the top entirely solid, of a mild taste, like the boiled white of egg, and almost scentless. This mass, being kept in the open air, by degrees sweats out a thin aqueous liquor, exactly after the manner of boiled white of egg; but if this coagulation be properly made with a moderate fire, or with a degree of heat barely requisite for that purpose, it concretes without any empyreuma, without

without separating any salt, or manifesting any sign of being alkaline; and when thus coagulated, it can scarce be resolved by any other means.

The use.

Hence it appears that all the fluids of the body may be coagulated or con-
creted into masses, not capable of passing the vessels, with a certain degree
of heat, not much greater than a hundred degrees; and therefore that the
body cannot endure a degree of heat, tho' but a little greater, whether from
an external or internal cause, without a stoppage of the circulating fluids,
and the death of the person: the defect first appearing in the brain and
lungs, the actions whereof are thus prevented. And hence we understand,
that the heat which coagulates the juices may prove mortal, long before the
salts and oils become alkaline, putrid, and volatile, by the same means. Hence
the little mercurial thermometers made by *Fabrenheit* are extremely useful in
all these cases; and hence just prognostics may be made from the degree of
heat in acute diseases.

PROCESS CXVIII.

The serum of the blood coagulated with alcohol.

TO a quantity of serum, contained in a clean vessel, pour a little pure
and cold alcohol, and the serum will immediately grow thick,
white, and opaque, where the alcohol touches it; and when the two are
shook together, all the same phenomena happen, and the whole is coagu-
lated as in the white of eggs, though not so strongly, but in pieces.
When the alcohol is poured on very hot, and shook with the serum, the
coagulation proves much stronger. The alcohol, thus poured on and coa-
gulating, preserves the serum from corrupting afterwards; so that it may
now be preserved, for years, unchanged.

The use.

1. Hence we find a new agreement between the serum of the blood, and
the white of eggs, in respect of their coagulating with alcohol. The reason
why the serum does not here coagulate into such a dense mass as the white
of eggs, seems owing to the greater solidity of the white of the egg, which is
entirely destined to nourish the chick contained in the shell; and is neither
in the least corrupted, nor so thin as serum, which retains some mucous
part of the blood, and much water.

2. But alcohol diluted with water does not thus condense the serum, nor
the white of eggs; and hence we may understand the effects of pure alco-
hol upon the blood, which it condenses like fire, and preserves from all
spontaneous putrefaction; and in both these respects it becomes an immediate
styptic; at the same time preventing putrefaction, and occasioning a thin in-
deed, but very solid escar. For if pledgets be dip'd in pure alcohol made hot,
and applied to a bleeding wound, if it be closely compressed upon the part,
and covered with a piece of bladder, lightly besmeared with oil, and kept

on.

on with a proper bandage, the hæmorrhage presently ceases; and the whole dressing may continue unremoved for three days, in which time the vessels are usually closed, and strangely contracted and consolidated by means of the alcohol. This liquor also coagulates the grosser juices of the body like fire, and contracts the fibrous parts, rendering them hard and dry, and preserves both from spontaneous putrefaction, as Dr. Cabelliau has shewn, by an extraordinary example, in a leg that was mortified, but by means of spirit of turpentine, and the alcoholized spirit of juniper, kept without amputation, so as not to putrefy farther for six months (a). But the parts of the body, consisting of small vessels, soon grow hard, together with their juices, in alcohol; whence it is no wonder that the persons, who use inflammable spirits too freely, are subject to such violent disorders of the nerves and concretions in the blood.

PROCESS CXIX.

The analysis of the blood by distillation.

TAKE the blood of healthy persons, drawn from the arm by way of prevention, in a plethoric habit; put it into a glass body, so as to fill only one third thereof; lute on a glass head, fit on a receiver, and work, in a bath-heat, with a fire of a hundred and fifty degrees. There will thus rise into the alembic-head, dewy scattered drops like pure water, without any sign of a fat spirit. Continue to work so long as any moisture comes over tolerably quick, with this degree of fire, and preserve this apart; it will have the gravity, the colour, and fluidity of water, and be almost without smell and taste; it makes no effervescence with any acid or alkali, but quietly mixes with them both: it manifests nothing saline or oily; when dropped into the eye it does not prove at all sharp; and quenches flame when thrown thereon: whence it is almost water.

2. Now raise the fire, so as to make the water of the bath boil, and a like aqueous volatile liquor comes over; continue distilling with this heat, till no more rises; which requires a considerable time, because towards the last, when the mass begins to dry, the liquor rises with difficulty. This second liquor, is in every respect, exceedingly like the first, so that all the experiments above related hold true thereof, without any difference: which is a thing I recommend to be carefully observed and remembered. These two liquors make almost seven eighths of the blood employed.

3. The glass-body being now broke, and the remaining mass taken out and examined, does not by any experiment seem alkaline, acid, or sharp, but unactive, and somewhat empyreumatical; and if kept in a dry place, included in a wooden unpainted box, it may long be preserved without change; or it may be reduced to powder, and thus preserved, as apothecaries do by goats blood.

(a) See *Ephern. Germ. Dec. III. p. 495.*

4. This

4. This mass being pulverized, and put into a glass retort, whose neck is cut off so as to leave a very wide mouth, and the retort remaining one third empty, distil with degrees of fire in a sand-furnace, and a somewhat unctuous, oily, bitter, and lightly alkaline liquor comes over; then a white, solid, volatile salt, sticking to the sides of the receiver and neck of the retort. Increase the fire by degrees, and thus a gold-coloured oil, always attended with salt, will be forced over. Apply a fresh receiver, and use a strong fire of suppression; white fumes will now ascend, and would, perhaps, never cease, and along with these a gross fat oil: and now the mass at the bottom of the retort, being fused, rarified, and swelled, rises into the neck of the retort, which it blocks up, and, with a violent noise and force, instantly bursts the vessels to pieces in a dangerous manner, as I have learnt by experience: this may be prevented by choosing a retort with a wide neck, and cut short, so as to leave a very open mouth. There are thus obtained an alkaline oily spirit, a volatile alkaline oily salt, a salt a little more fixed and more oily, a yellow oil, and one that is black and pitchy; all of them containing alkali, exactly as we found in distilling the white of eggs, according to the hundred and twelfth process, from which the present differs but little.

5. At the bottom of the retort, there remain very black, shining, spongy, light, fetid, empyreumatic, bitter, but scarce saline faeces, which, being urged in a close vessel, till the retort was almost melted, I could not by the force of fire bring to that state, as to fume no more: this matter still retained its blackness, so that it is the true coal of blood. If urged with an open fire, it takes flame, the blackness is consumed, and a white earth left behind; in which no fixed alkaline or acid salt can ever be found, tho' it often contains sea-salt, unchanged by the vital actions: so that if distilled with the utmost violence of fire, along with its own earth, it might afford some acid. All these particulars therefore shew, that the white of eggs, and the serum of the blood are nearly the same thing; only that one is at rest in the shell, and the other briskly circulated thro' the vessels of the body. They who have wrote that phosphorus may be obtained from this last matter, may perhaps say true; but I question whether they spoke by experience, because there is so little of these faeces left behind by the blood. It is easy to argue by analogy, but much more laborious by experiments.

The use.

Hence it is certainly shewn, that water, and a somewhat fetid spirit, are the most volatile parts in the juices of the body; that water makes by far the greatest part thereof; and that the natural salt of the blood is never so volatile in the body, as to rise with a heat twice and a half as great as that of the body, or even almost thrice; whereas a degree of heat, one tenth part greater than that of the body in health, soon proves mortal. Hence also it is manifest, that no volatile alkaline salt can rise with a degree of heat three times greater than the natural; and consequently that such salt is not then present: that the pitchy oil strongly coheres with the earth of the blood;

blood; that the blood, deprived of water, manifests no saline principles, and that these at that time neither act or are changed, but may lye mixed together at rest, and unactive for years, tho' they may be extricated by fire; that the blood may be inspissated by fire, so long as the heat continues less than is required to make the blood afford a volatile alkaline salt; that the blood inspissated with this degree of heat, may again have a large part thereof converted into a volatile fluid by a stronger fire; and that the parts so separated may, except a very little earth, remain afterwards fluid and volatile. We have seen that there are no inflammable spirits in the blood; that the salts of the blood which are not at first volatile with two hundred and sixty-six degrees of heat, yet when once rendered volatile, can scarce be kept from spontaneously flying off with a heat of thirty-two degrees; that the salts of animals may, by a strong fire be rendered volatile and alkaline, tho' they were not so before, and be made to remain in this state: that the separated principles of the blood do not, when mixed together again, recombine blood, but make a very different thing; and therefore that fire acts with a strange diversity upon the blood, according to the degree wherein it is applied: below a hundred degrees, down to fifty, it attenuates and putrefies it; from a hundred up to a hundred and seventy-six, it inspissates it; and beyond this degree again, it attenuates it, and renders its parts volatile, sharp, and alkaline; and hence we may understand what the aliment, the chyle, the milk, the serum, and the productions thereof are in their origin, kinds and effects; and all these particulars I have found perfectly the same in the blood of many brutes.

PROCESS CXX.

The analysis of horses hoofs, by distillation.

1. TAKE the parings of horses hoofs, whilst at grass, as they are cut off by the farrier, and steep a sufficient quantity thereof in water, that they may be cleansed, and afterwards dried; put them into a glass retort, so as to fill it almost to the neck; set the retort in a sand furnace, apply a very capacious receiver, and lute the juncture with a paste of linseed-meal; distil with slow degrees of fire. There will first come over a limpid aqueous liquor in dewy drops; continue the same heat so long as this liquor distils; then pour it out, and keep it apart; apply the receiver afresh, and raise the fire, till white clouds begin to rise, at which time a fat spirit will come over in oily veins; continue with this degree so long as it will bring any thing over; there will be now some signs of a saline matter. Increase the fire again, and along with the untenuous spirit there will come over a volatile alkaline salt, shooting up in little lumps, together with an oil; continue this fire till scarce any thing more rises; then increase it to the utmost; at length raising a fire of suppression; a somewhat more fixed volatile salt, along with a very thick red oil, will now come over; at which time the faces fusing will run into a mass that swells and rises up to the neck of the retort. Now cease the operation, and take away

Always the receiver before the retort is thoroughly cold, otherwise the volatile salt will in a great measure go back into the retort: keep the productions in a well-stopped glass, for they are exceeding volatile. The remaining faces are very sharp, light, spongy, as also fetid and bitter, and, if calcined in an open fire, afford a little quantity of white, insipid, and considerably pure earth.

2. If hartshorn, which has been kept for many years, and is now grown exceeding dry, be broke into large pieces, and put into an iron pot set in a furnace, and fitted with a large earthen alembic-head, that goes with a double pipe into two capacious receivers, and the distillation be carefully performed with degrees of fire, nearly all the same matters will be obtained; viz. a fat, oily, alkaline spirit, a volatile salt, a light oil, a salt somewhat more fixed, and a gross pitchy oil; there will remain behind a solid black coal, that does not easily dissolve by fire, but remains brittle, and when reduced to powder, and given upon an empty stomach, it proves an excellent medicine for destroying worms.

3. The recent bones of animals, cleared as much as possible from their fat, and treated in the same manner, afford the same matters; only abounding with more of a highly fetid nauseous oil, that infects every thing it touches. Horns, nails, hoofs, hair, and silk afford the same.

The use.

As a greater or less quantity of water is drawn from all these, even the driest bodies, it shews how intimately water may adhere to the other principles of animals, and be consolidated therewith into an extremely hard and dry form, so as to remain fixed for numerous years, and at length be released again by the means of fire. This principally appears when the fluid spirit is separated from its volatile salt and oil; for then a considerable quantity of fetid water is left behind: and hence it appears, that the most perfectly inodorous bodies may, by the bare force of fire, acquire many degrees and kinds of fetid odours, whilst each part, separate from the rest, has a peculiar odour, which it tenaciously retains for a very long time: and the same holds true of the variety of tastes produced from an insipid body: for the water, spirit, salts and oil, have each their particular odour. Again, from a solid body we have various fluids, which concrete together again with the greatest difficulty, so as to form a fixed body; we have several also that are volatile from fixed bodies; and there remains from so large a bulk but little earth, which is firm and fixed. And as the same principles are obtained both from the solids and fluids, tho' always more earth from the solids; we hence see the common nature of both, and therefore that the solids are composed of the fluids; but the larger bones calcined to perfect whiteness, both in their surface and substance, with a clear and violent fire, still retain the former size and figure; yet if afterwards exposed to the action of the fire in a close vessel, they afford no water, salt, spirit, or oil, but remain crumbly, yet so, as if dipped into water, or oil, they again acquire a tenacity. So likewise if horns, bones, or the like parts, be strongly boiled for a long time in water, with a repeated change of the water, and a separate reservation of the former decoctions, and this be con-

tinued till the water comes off pure, after boiling with the bone, and all these decoctions be inspissated to a thick coagulated mass without burning, so as to appear almost like horn in the cold; then this mass, so prepared from hartshorn, ivory, bones or flesh will, by distillation, afford all the principles, in the same manner as the other subjects of this process. But the horny or bony matter, remaining after this thorough decoction, affords so much the less salt, oil, and spirit, the more jelly was obtain'd by the boiling; from whence it seems, that all the saline, spirituous, and oily matter proceeded only from the juices, whilst the last solid is a mere simple earth that can scarce cohere together, and containing, after having suffered the utmost violence of the fire, no fixed salt, but always affording, when burnt to whiteness, a proper kind of ashes for making the refiners tests. And when bones are treated in *Papin's* digester, I have found, by repeating the operation, that they remain almost wholly terrestrial after boiling. And this has shewed me that scarce any observable difference could be found in these productions, let the animal subject be what it would; except only in respect of the oil, which abounds more plentifully in one part, than in another. The oil, in the distillation acquires a perfectly intolerable fetid odour, that infects all the things it touches with an abominable taste and smell, not to be got out. And hence the solid substances, thus distilled, afford these productions the more infected and disagreeable, the more oil they contain: and hence it is that hartshorn, which is less unctuous, affords a less nauseous oil and spirit than ox-bone, which is full of marrow; but except this single difference, they can scarce otherwise be distinguished: for all these spirits and salts, purified from their oil, become the same thing; nor could I ever find any difference betwixt these productions, yielded by different animals: for horses hoofs, the horns of oxen and stags, ivory, tortoise-shell, hair and silk, afford all the same. Whence it is of little consideration from what subject these things are produced; only with respect to the oil, as above explained. I could never find that the spirit of human blood, hartshorn, horses hoofs, or raw silk, differed in any thing but the oil. *Helmont*, I know, recommends the saline spirit of human blood before all others, because it cures the falling-sickness; and in *England*, *Goddard's* drops, distilled from silk, are preferred to others of the same kind; but I have long observed, that these differences are seldom found with any certainty in the practice of physic. This is certain, that all the matter capable of affording these principles by distillation, may be extracted by dissolving animal solids in boiling water; whilst what remains, after a thorough boiling, will afford little thereof: therefore in these almost insipid and scentless decoctions, all that matter lies concealed, which affords salts, spirits, and oils by distillation; therefore these salts of animals could not be rendered alkaline or volatile, by so long and repeated a boiling. It is also certain, that the air, water, and sun, do at length deprive the bones exposed thereto, of all that animal matter, which, in distillation, would afford water, oils, salts, and spirits; and in old bones grown thoroughly white, is found, upon committing them to distillation, nothing of these principles, but only a simple earth; putrefaction having carried away the rest. It is an agreeable experiment to boil an animal muscle, or for example, an ox's

heart, so long in several waters, till at length the last water comes off as pure as it was put on; then gently squeezing the water out of the heart with the hand, and repeating this several times, and boiling it in fresh water, the external thin membrane being taken off, that the fat also may be resolved and separated in the boiling, there will thus be at length obtained a perfectly solid, dry, and incorruptible muscle, exhibiting all the fibres, especially if hot water has been first injected with a syringe, thro' the coronaries, so as perfectly to wash out the blood from the veins and arteries; for thus the mere skeleton of the muscle will be obtained.

PROCESS CXXI.

The manner of depurating and separating the productions of distillation from alcalescent, burnt, or putrefied vegetables, according to the thirty-third, eighty-sixth, and eighty-eighth processes; and again, from animal subjects, according to the ninety-fifth, hundred and first, hundred and twelfth, hundred and nineteenth, and hundred and twentieth processes.

1. **T**AKE all the productions of distillation in the processes here mentioned, and put them together into a large glass-body, to be hereafter kept for this purpose; apply a large capacious head, with its pipe cut in the wide part, so that the salt may easily pass into the receiver, otherwise it would there stop, block up the pipe, and forcibly throw off the head. Set the vessel in a bath-furnace, with a continued heat of a hundred and fifty degrees, so as first to bring over what will rise with this degree: a fat, volatile, alkaline spirit thus comes over, along with a white solid salt. When no more ascends, change the receiver, and keep this liquor, with its volatile salt, apart; and if the salt, by shaking, does not dissolve in its spirit, it is a sign that the spirit, being poured out, and kept separate, is as strong and rich as can any way be procured: let it therefore be kept for its particular uses, in a close-stopped glass, under the title of spirit of hartshorn, spirit of human blood, &c. And let the salt also, which would not dissolve in this spirit, be preserved under the title of the volatile oily salt of hartshorn, or of whatever else the subject was.

2. Urge the remainder with the heat of boiling water, and there will come over another spirit more slowly than the former, together with a light oil floating thereon, and some quantity of volatile salt: continue thus till no more rises with the same degree of heat; and again, keep this aqueous, oily, and saline liquor separate: a gross fetid oil will now remain at the bottom of the vessel.

3. Thus we obtain, from the above-mentioned productions, a water that is neither oily nor saline at first, as we saw in the beginning of the preceding process; next, an alkaline oily spirit; thirdly, a volatile oily salt; fourthly, a volatile oil, with an oily alcali, a little more fixed, and a fetid

water; fifthly, a more fixed oil than could be separated by a heat of two hundred and thirteen degrees.

4. If the first spirit be again distilled in a fresh glass, with a hundred degrees of heat, the salt is thence obtained purer, and almost in a solid form. And if the operation be continued, till the salt sublimed begins to dissolve by the subsequent liquor, an aqueous fluid will remain at the bottom, with an oil floating thereon: so that these spirits consist of an extremely light water, oil, and salt united together; whence they again resolve into these three. This spirit therefore is a volatile saponaceous lixivium; and the remaining water and oil may be so separated, by a fresh distillation, that the water shall remain tasteless, tho' fetid, and the oil almost without mixture; all the salt being separated with the more volatile oil: and hence we may understand the nature of these spirits. But the salt separated, by this sublimation, from its spirit, is always oily, tho' less so than the former, and therefore much whiter; because upon each rectification it leaves a yellow, and sometimes a red oil behind, which gave it the colour. But when the spirits that are not oily, as those of the hundred and sixth process, but merely alkaline and aqueous, are thus treated, then only a pure volatile alkaline salt arises by itself, in a dry form; leaving the water so much less alkaline at the bottom. Hence we learn, that the animal salt, once rendered volatile and alkaline by putrefaction, the admixture of fixed alkali, or the force of fire in distillation, thereby becomes and remains more volatile than pure water, and the most volatile oil: and hence, that the water, so deserted, manifests the oil it concealed before, as being united with its alkali into a kind of soap, soluble in water: and now, when the alkali is separated, the oil will no longer continue mixed with the water, but fluctuates apart.

5. Let the oil, which remains after the depuration of the spirits, be poured to that remaining at the bottom, as above-mentioned, and mix'd therewith; then pour warm water to them, and shake them together, whereby the salt, that might chance to remain fixed with the oil, will be dissolved in the water; and hence the caustic sharpness of the oil will be got out, and the oil itself be rendered more mild: let this saline water be poured off, that the salt may afterwards be separated from it by sublimation. Then let these oils be put into a glass-body, and with the heat of boiling water be freed from their aqueous moisture, till no more thereof will arise; then put the oils into a retort, and distil, with a gentle heat, into a capacious receiver, gradually increasing the fire to the highest degree sand will give, till nothing more comes over; and thus the oil will become more thin, limpid, and less fetid: a black earth remains behind in the retort: and if the oil, once drawn off, be a second time returned, and distilled upon its own black faeces, it again becomes more pure, limpid, thin, and less fetid; again leaving more earth behind; and this happens upon numberless cohabitations. But I have scarce found any end in the operation; for I have formerly, according to the direction of *Helmont*, in his *aurora medicinae*, endeavoured, with great patience, to prepare the oily diaphoretic medicine he there prescribes; and he directs the purification of these oils by distil-

lation,

elation, so often repeated, till at length they leave no earthy faeces behind. I, therefore, distilled oil of hartshorn in the manner above-mentioned, and cohobated it a number of times, but always found a black feculent matter left behind; so that I at length lost a part of the oil, and gained a great quantity of earth, and still found more earth at the bottom of the retort. But thus I obtained a very penetrating, and not ungrateful oil. Whence I conceive that *Helmont*, perhaps, never brought the experiment to a conclusion, in the manner he directs it; and that the illustrious *Mr. Boyle*, with greater veracity, writes in his treatise concerning the transmutability of the chemical principles, that, by many continued cohobations, at length almost the whole quantity of these oils is converted into earth, with a constant loss of that acrimony which remains in the oil after the salt is washed out. In the mean time, it is worth the while to cohobate these oils fifteen times over: for thus they will become thin, pellucid, penetrating, and volatile, almost like spirit; of a penetrating taste and odour, and will strangely enter all the parts of the body. They are anodyne, soporiferous, and resolving, good in fevers, and grateful to the nerves, and cure intermittents by being rubbed externally along the backbone, before the cold fit. Their dose is from twenty to thirty drops (a). And thus these oils are reduced to a very large quantity of earth, and a very small one of true oil: and thus the greater part of them at length nearly acquire the same nature, and afterwards can scarce be distinguished from one another: so that all distilled animal oils, thoroughly depurated from the other principles, seem to be one and the same thing, from whatever animal they were obtained.

6. The volatile salts of animals are depurated several ways, so as to render them at length perfect and without mixture. (1.) Take a large cut glass-body, and put into it the volatile salts to be rectified; apply a glass-head with a capacious receiver, and distil with a gentle sand-heat; the salt will rise into the head and the neck of the glass; continue the operation till no more rises. Let the salt be taken out, and kept in a close glass; an oil and a fetid matter will be left behind. But in this method some oil always rises with the salt; tho' it may, by sublimation, be in a great measure left behind, and the salt be obtained the purer. And thus the salt of urine, white of eggs, blood, horns, and bones, are made to appear as the same thing: for by repeated sublimation I have brought them to such a likeness, that I could scarce distinguish between them; and this always the less, the oftner the sublimation was repeated: whence it may appear, that all the difference of these volatile salts depends wholly upon the empyreumatic oil adhering thereto; which, when perfectly separated, leaves them all alike: but the salt, whitened by this operation, grows yellow with keeping; the oil, that was concealed, thus again manifesting itself. This those chemists find, to their disadvantage, who prepare salt of hartshorn for sale; where an agreeable and permanent whiteness is principally required. I have therefore found the following method more suc-

(a) See *Dippel*, and *Hoffm.* Obs. Chym. Phys. cap. 1.

cessful. (2.) Put the salt, obtained by the preceding sublimation, into a tall glass-body, and immediately throw thereon four times its weight of pure, hot, dry chalk, reduced to fine powder, so as every way to cover the salt; then immediately lute on a dry alembic-head, which, the larger it is, and the wider its pipe, the better; lute on a receiver, and distil with a warm heat in water: all the salt will thus rise white, pure, alkaline, and volatile, whilst nearly all the oil is detained in the dry and thirsty chalk. In the mean time, this addition of chalk will not change the nature of the salt, but only keep back its oil, and thus separate it from that foulness; and the salts, thus prepared, may be long kept without changing; especially, if before sublimation, they were well ground with the chalk: but in that case much of them would be lost, or fly off into the air in the grinding, and the remainder would presently dissolve by attracting the moisture of the air. (3.) Lastly, if, when the salt is thus depurated, by means of chalk, as much pure spirit of sea-salt be mixed therewith, as suffices to saturate it perfectly, and the sal-ammoniac, thus produced, be dissolved in water, perfectly filtered, and inspissated into a salt, and this salt distilled with fixed alkali, according to the hundred and sixth process, a pure, solid, white, alkaline, salt rises, which is the most genuine that can be procured, and perfectly free from oil: this beautiful invention is exactly described in the *Philosophical Transactions* (a). When these volatile, alkaline, oily salts are, by these three methods, reduced to their utmost purity, there appears no sensible difference between them, whether they were spontaneously generated in the subject, or produced by putrefaction, or by fire; and they are obtained perfectly in the same form from birds, land animals, and amphibious creatures, fish, reptiles, subterraneous animals, alcalescent vegetables, foot, &c. for as they all, when deprived of their spirit and oil, afford the same species of sal-ammoniac, along with the spirit of sea-salt; so this sal-ammoniac, being afterwards resolved by fixed alkalies, affords the alkaline salt and spirit of the hundred and sixth process. Hence, therefore, pure volatile alkali is but one thing in nature, when obtained pure; but the difference found in it always depends upon the admixture of some other principle, especially the oil cleaving thereto, which is very different in different subjects, altho' the principal difference of the oils is owing to a very small quantity of spirit. Hence we see, that the water, earth, and salt of animals, when, by the means above-mentioned, reduced to their utmost simplicity, are perfectly the same without any difference; so that the peculiar characteristic of each is principally lodged in the oil alone; the oil itself being distinguished by its spirit, which, when perfectly taken away, oils themselves also become wonderfully alike. This presiding spirit, therefore, constitutes the true difference in animals, as we above observed it did in vegetables: and these are the ultimate and simple effects of a chemical analysis. If the artist here endeavours to proceed farther, he will be in danger of losing his subject; the particles whereof are now apt to fly away: for when the principles are thus purified, they do not greatly

(a) *Lewth.* abridgm. vol. III. pag. 335.

'cohere together; tho', by differently uniting with one another, they form
'a vast variety of compounds.'

The use.

The chemical properties and virtues of this pure, volatile, alkaline salt are chiefly these. (1.) It makes an effervescence with all the known acids, as strong and as durable as fixed alkaline salt; closely joins the acids with itself, and retains it so as to form a compound salt according to the nature of the acid. And thus, when fully saturated, it increases $\frac{37}{14}$ in its weight. Whence we may understand the requisite proportion for making the balance betwixt acid and alkali, and how much of either may be again expected upon the resolution of these compound salts. But as soon as the point of saturation is exactly gained, the action of the salt, so produced, is neither to be estimated from the acid or alkali of the composition, but from the new nature the compound salt has acquired. And hence the error of those may be easily confuted, who conceive that the virtues of compound salts are such as they observe in the parts produced by a separation. (2.) This salt, actuated with the heat of the healthy body, presently inflames, burns, and causes a gangrenous eschar, and therefore perfectly destroys all the parts of the human body to which it is so applied, as that its motion, arising from the heat, may be driven in upon the part. Thus, if a scruple of the pure volatile salt of hartshorn be laid upon the skin, and covered with a sticking plaister, it will in half a quarter of an hour raise a black carbuncle, as if a piece of hot iron had been there applied; and the colour, pain, heat, and hardness of the skin, are also the same as they would be in that case: and it resolves the humours into a thin, sanious liquor. (3.) It is the most moveable body of any hitherto known, as exceeding even alcohol in volatility: for if alcohol, water, and this salt be put together in a tall chemical glass, fitted with an alembic head, and a small degree of heat be applied, the salt will rise by itself into the head long before the alcohol; the alcohol will next follow, and the water at last with difficulty. And thus this salt flies off from every heating point, and if laid upon the warm hand, it presently flies away without hurting the hand, as in this case its reaction is not great upon the heating body; wherein it greatly differs from the fixed alkaline salt, which adheres by its weight. But when these volatile alkaline salts are received into the vessels of the body, and there actuated by the vital heat, and the force of the circulating fluids, they act very powerfully by a sharp, stimulating, and corroding virtue, especially upon the more sensible, fine fibres of the nervous system, which they excite to greater motion; and at the same time thinning the humours, promote perspiration, sweat, urine, and *saliva*. They likewise frequently prove serviceable upon receiving their volatile exhalation, along with the air, into the nostrils; for thus they irritate the *membrana pituitaria* of the nose, mouth, jaws, lungs, and, by irritating thereof, dissolve the viscous phlegm, that may adhere thereto, provided they be used with caution. (4.) These salts, therefore, are proper, and have very good effects in aqueous, acid, and austere distempers of the humours, as also in torpidity of the nervous system, and disorderly

derly motions of the spirits, rushing irregularly and involuntarily into particular muscles. And hence they excellently cure hypochondriacal, hysterical, epileptical and spasmodical disorders. Being diluted with water, and received in the form of vapour into the *vagina uteri*, they are esteemed one of the most immediate remedies, when prudently applied, for promoting the menses if required. But they prove poisonous in alkaline and putrid disorders, where the humours are dissolved, and the body already too much agitated. They may be also externally applied, in the way of a caustic, for the making of issues, the extirpating of warts, and taking off styes upon the eye-lids. The method of using this salt in these cases, is by laying it upon a little pellet of lint, and applying it to the part; then covering it with a sticking plaister, and leaving it thus, till it may be thought to have performed its office.

P R O C E S S CXXII.

A soap prepared from pure volatile alkaline salt, and alcohol.

“TAKE the alkaline spirit of sal-ammoniac, so strong as to leave much of its salt undissolved at the bottom; put it into a cold and dry cylindrical glass, with a narrow mouth, so as to fill about one half thereof: pour to it gradually a quantity of pure cold alcohol, so as to run gently down the sides of the vessel till it be full; a white coagulation will be made upon the surface where the lighter alcohol rests upon the alkaline spirit. If the glass be now inverted, there will instantly appear a white opaque coagulation, where the alcohol and alkaline spirit mix; and when they are both well shook together, the whole immediately becomes a white, opaque, consistent mass, concreted together like stone, so that not a drop will fall out of the glass while inverted. Stop the vessel close, and set it by; thus the mixture will soon resolve into a fluid, that floats at top, and a dense saline concretion that falls to the bottom; so that in a year's time the salt will almost become solid below, with a liquor floating above it. If the whole mass, thus produced, be distilled with a soft fire; an alkaline, balsamic, oily, solid salt will sublime: and the colder the season and the place, in which the experiment is made, the better it will succeed.”

The use.

This is one of the more difficult experiments in chemistry, as requiring both the liquors to be perfect, and the observance of several circumstances, any one whereof being wanting, will cause it to miscarry; but if they all be observed, it will always succeed. Here we see, therefore, that pure volatile, alkaline salt, will closely attract to itself the most subtile oil that is known, viz. alcohol; whence the soap, so produced, is the most subtile and penetrating of all soaps, as consisting of an exceeding subtile, and volatile alkali and oil, wonderfully united together in an instant. If this medicine be diluted with *Canary*, and taken upon an empty stomach, it passes, perhaps, thro' all the vessels of the body, resolves concretions, opens obstructions, ex-

cites

cites the vital powers, and thus successfully cures many dangerous distempers, proceeding from an obstructing matter, capable of being resolved thereby. But its virtue vanishes too soon, as being so extremely volatile, and therefore becomes unequal to the more stubborn distempers. It is highly commended in the jaundice, unattended with an acute inflammation; it does not dissolve the stone, or prevent the concretion or increase thereof; it seems to agree with salt of tartar rendered volatile; it dissolves in a gentle heat, like ice, and returns to a solid form in the cold. If pure alcohol be thus mixed with one third of dry volatile alkali, it makes a much more solid soap, as being without water, which is always double the quantity in the strongest alkaline spirit, with respect to the pure salt. *Helmont* needed not have apprehended the sudden generation of the stone from hence; for this matter is not the stone, but dissolves with heat, dilutes with water, and proves totally and spontaneously volatile; so that it has nothing in common, nor alike to the stone. *Helmont* was not the inventor of the experiment, tho' the production be called *offa Helmontiana*, but *Raymond Lully*, long before him; and the *English* author upon the alcahest, supposed to be *George Starkey*, inconsiderately pretends, that this soap brought to a liquor, by repeated distillation, will become the alcahest of *Helmont*.

PROCESS CXXIII.

The aromatic simple sal volatile of angelica.

1. TAKE two ounces of the slender recent roots of angelica, dug up in February, and cut small; put them into a glass retort; pour thereon twelve times their weight of spirit of wine, once rectified from its watery part; add an ounce of bruised sal-ammoniac, and three drachms of salt of tartar. Lute on a receiver, and distil with a gentle fire, not exceeding a hundred and fifty degrees. There will come over a white, alkaline, and alcoholised salt into the receiver; and when this ceases to rise, increase the fire a little, and the spirit of wine will ascend in very oily veins; continue this fire so long as this spirit comes over. But when the first salt is wholly dissolved by the last aqueous part that rises, stop the operation, and put the liquor into a close glass; the remainder may be thrown away.

2. Put an ounce of fresh root, cut small, into a clean retort, and distil as before, with the liquor already obtained, and continue till the salt begins to dissolve; then shake the spirit and the salt well together, and put them into a glass that is to be kept well stopped, under the title of the simple aromatic sal-volatile of angelica.

The use.

The alkali of tartar, here drinking in the acid of the sal-ammoniac, as explained under the hundred and sixth process, sets free the alkali of the sal-ammoniac, which therefore becomes volatile; and uniting with the pure spirit of wine, makes the sal volatile of the preceding process; to which the

presiding spirit of the angelica joins itself, by mixing with the alcohol; for this spirit presides in the balsamic and oily part of the root, and is extremely volatile. And hence, as the nature of alcohol is indeterminate of itself, and joins with all spirits of vegetables alike, it is here determined by the spirit of angelica, so as to become the spirit thereof, according to the sixty-ninth process. In the mean time, the volatile and fixed alkaline salts, and the acid spirit of the sea-salt assist, in the distillation, to open the body of the angelica, and make it the more easily part with its spirit, and its oil thus dissolved. Hence the liquor, thus procured, does by its odour, taste, penetrability, mobility, saponaceous virtue, and the power it has of correcting what is acid and austere, afford a remedy of singular efficacy, in the hands of a prudent physician. For it is excellent in all watery, mucous, cold, acid, austere distempers, where the efficacy of the bile is wanting, and in all sluggish disorders unattended with inflammation or putrefaction, especially when the disorders, or unequal motions of the nerves and spirits, occasion troublesome hypochondriacal and hysterical fits, with the flatulencies thence proceeding. Hence it is at present accounted a noble restorative, stomachic, warming fudorific, diuretic, diaphoretic, antiparalytic, antispasmodic, and anti-epileptic medicine, where the distemper proceeds from the causes above-mentioned. We are obliged to *Basil Valentine*, and particularly to *Sylvius*, for introducing this noble kind of medicine; tho' the followers of *Sylvius* often bring it into disgrace by an unseasonable use. Our present process serves for a general example; for any other aromatic being substituted in the room of angelica, its presiding spirit will afford a new remedy, which may be advantageously obtained from the flowers of lavender, rosemary, or the like.

PROCESS CXXIV.

The preparation of a compound sal volatile oleosum.

TAKE twenty-four ounces of the compound spirit, described under the seventy-second process; put it into a glass retort, add six drachms of salt of tartar, and two ounces of powdered sal-ammoniac, and distil as in the preceding process; there will arise a white, alkaline, spirituous, oily salt, which may be kept apart.

The use.

This is another method, and better than the former, of producing aromatic, volatile, oily salts for medicinal use. It may be easily understood from what is above delivered under the sixty-ninth, seventieth, seventy-first, seventy-second, the hundred and sixth, and the hundred and twenty-third processes; for the spirits here kindly uniting, they afford noble remedies, if cautiously and seasonably used, and may be varied infinite ways at every one's discretion.

PROCESS

PROCESS CXXV.

A particular preparation of sal volatile oleosum.

THIS title promises a remedy of some peculiar virtue, directed to a certain medicinal end: for example, if a volatile salt be required for bringing away the birth, the *lobelia*, &c. take the distilled oils of juniper, rue, savine, and *arbor vite*, of each two drachms; dissolve them in twenty ounces of alcalified alcohol, according to the sixty-seventh process, into a quintessence, to which add two ounces of pure, dry, volatile, alkaline salt, and shake them well together; they will thus unite tolerably, provided the salt were sufficiently dry, and thus the medicine required is obtained.

The use.

This is a third method, and no bad one, of procuring a *sal volatile oleosum*; and if it be previously known from botany and medicine, what the virtue of every plant is, so that chemistry may be certain that their particular virtue resides in their oils, then we can by this method prepare such salts for particular purposes. Thus, cephalic salts may be obtained with the oils of lavender, rosemary, and marjoram; cardiac salts, with the oil of the peel of orange, citron, lemon, cinnamon, nutmeg, and so of the rest.

PROCESS CXXVI.

An extemporaneous sal volatile oleosum.

1. TAKE one part of salt of tartar, three parts of sal-ammoniac, twelve parts of aromatics, reduced to powder, and twenty-six parts of rectified spirit of wine; mix them together, by long shaking in a bolt-head. The alkaline salt will thus immediately unite with the alcohol that floats above, the water being attracted into the salts; at the same time the salts and spirits will attract the oil out of the spices, and thus the liquor, that floats above, will presently become the *sal volatile* required; as the famous *le Mort* has observed.

2. Or, take three parts of salt of tartar, and nine of sal-ammoniac; put them into a glass-body along with one part of any distilled aromatic oil; and directly sublime into a large head, with a gentle fire, barely sufficient to raise the salt; keep the fire in this degree so long as any salt sublimes, then have ready a clean, dry, and cold glass, close fitted with a glass-stopper; and now taking off the head, break off the salt with a bent iron rod upon a paper, or glazed dish; then bruising it a little, presently put it into a store-glass for use. This is a saponaceous, volatile, oily salt, according to the nature of the oil employed, and of frequent use in *England* against hystERIC fits, &c.

Thus we have gone thro' the various ways of preparing these volatile oily salts, which are nearly related, as their virtue depends upon a volatile soap, united with alcohol, and the presiding spirit of vegetables. The practice of physick throughout Europe, turned chiefly upon the use hereof, after the famous Sylvius published his *praxis medica* in the year 1671, Otto Tachenius, his little treatise *de morborum principe*, and Bonetoe his works. But in inflammatory distempers, where the juices are dissolved and putrid, in the alkaline scurvy, the phthisic, consumptions, and other cases, where the body is almost dissolved down, they often prove highly pernicious, and sometimes destructive. Physicians, therefore, are to be seriously admonished against permitting men, and, particularly, women of a weak constitution, the frequent use of these salts in the way of smelling-bottles, whereby the olfactory nerves, and others are spoiled, and the fine arteries of the nose and lungs easily disposed to hæmorrhages, which are always dangerous, and sometimes mortal.

And thus I hope to have shewn the true chemical analysis of the parts of animals; and again, the method of combining these separated parts into various forms, for chemical and medicinal use; whence it appears, that by putrefaction, and the distillation of putrefied and crude substances, there may be obtained, (1.) A certain, somewhat fetid, volatile and thin spirit, mixed with water, and difficultly separated from it. (2.) A water, nearly approaching to elementary, excepting only that it can scarce ever be separated from its spirit. (3.) An alkaline, volatile salt. (4.) A thin volatile oil. (5.) A thicker oil. (6.) An earth, in all cases the same. (7.) Phosphorus, containing a strong ponderous acid. (8.) Sea-salt, when this has been used in the meat or drink, otherwise not. It next appears, that these productions, however depurated, separated, and brought to their utmost perfection, cannot by any art be compounded, so as to exhibit their original form and virtues; but are changed into a new body, which has scarce its like in nature. What wonder, therefore, if all the parts of animals become volatile by putrefaction, and either go off into the air, or sink into the pores of the earth, whilst what was thus carried off, into the air, is again returned, and mixed with the earth in rain, mist, dew, hail, and snow? What wonder, therefore, if the principles of vegetables should hence arise, that are convertible, by a seminal power, into their former nature, and thus enrich the exhausted earth for supplying food to animals, by whose vital powers they are converted into the substance of their bodies? Certainly, so much as the earth loses by feeding plants and animals, it again receives from them upon their destruction and putrefaction.

PROCESS CXXVII.

The phenomena of the blood and serum, from the action of the air, water, fire, salts, acids, alkalies, spirits, oils, and soaps thereon.

1. **HEALTHY** blood concretes into a cake in air, heated from thirty-two to ninety-four degrees; it separates into serum and a red coagulum; it again resolves, becomes liquid, putrefied, and volatile, and at length goes off into the air, except a small fixed part. In air that grows cold, from thirty-two degrees of heat to one, and lower, it concretes sooner, freezes, and thereby separates its water from the other principles, which are drove into one mass apart. While it remains thus frozen, the water is soon dissipated from it, and continually diminishes surprisingly; the remainder being thawed, presently resolves into a corrupt liquor, that putrefies, becomes extremely volatile, and thus readily flies off into the air. In an air heated to a hundred and twenty degrees, which is never found in the atmosphere, it presently begins to coagulate into a concremented mass, and so up to two hundred and fourteen degrees, but afterwards resolves with a greater heat. It admits the air equably divided among its particles, but this only in a certain proportion; and to endeavour, by shaking, to mix more with it, is in vain; for the air is either repelled, or entangled, and separated into bubbles.

2. It first dilutes in water, heated from thirty-two to ninety-four degrees, but soon after coagulates. It also coagulates with a boiling heat, and therefore cannot be kept fluid by water, without the grinding motion of circulation; neither can bare motion, or brisk shaking, preserve its fluidity, or resolve it when coagulated out of the vessels of the body, not even tho' this be done in water, as the famous *Ruysh* found by a particular experiment, but it concretes into a viscous mass. It putrefies in water, if exposed to the air; whence it is not true, that cold or warm water dilutes the blood, but spring-water seems to coagulate it more than rain-water.

3. The degrees of fire, from thirty to a hundred, putrefy, resolve, separate, and volatilize the blood: a greater heat coagulates it, up to two hundred and twenty degrees; but a greater than this again resolves, and suddenly putrefies it.

4. The acids of *Moselle* and *Rhenish* wine, vinegar, and distilled vinegar, dilute the blood, scarce alter its colour, and in some measure prevent its coagulating. The acid of nitre instantly coagulates it, and turns its colour bluish; the acid of sea-salt likewise soon coagulates it, and changes it of a grey colour, inclinable to black: the acid spirits of vitriol and sulphur also bring it to a firm mass, which is generally whitish.

3. Volatile

5. Volatile alcali scarce coagulates it, but preserves it red. Fixed alcali rather dissolves, than coagulates it: *Sal volatile oleosum*, in some measure, coagulates it: sal-ammoniac, nitre, sea-salt, sal-gem, and borax, heighten and preserve its colour, and somewhat prevent its coagulating; so likewise do the common and philosophical soaps. Alcohol coagulates it; oils make it more viscous. In all these experiments there is no sign of effervescence, or ebullition; but the colour and consistence are the principal things which we here find to be changed. Regenerated tartar, well prepared, preserves, or heightens the colour of the blood, and excellently preserves its fluidity: the liquor of tartarised tartar does the same; and *Venice* soap has nearly the same effect. But *Helmont's* tincture of salt of tartar, in respect of the alcohol, whose quantity is large, rather coagulates it; tho' in respect of the other ingredients, the effect is less sudden. The best *sal volatile oleosum*, undiluted, rather somewhat thickens the blood, on account of the alcohol. The compound liquor of the spirit of vinegar, and volatile salt, made according to the hundred and eighth process, excellently attenuates and dilutes the blood, and preserves its natural colour.

6. Metals, dissolved by acids, and thus made into a compound salt, and afterwards dissolved in water, so as fully to saturate it, wonderfully and suddenly change both the colour and consistence of blood; such as the solution of the vitriol of iron, which coagulates the blood, and turns it almost black; so does the solution of lead with vinegar, or spirit of nitre: mercury-sublimate also has almost the same effect: and the oil of quicksilver, which I prepare with the strongest oil of vitriol, and quicksilver, has the same effect in a very strong and sudden manner. Whereas these mercuries, when given in a small dose, soon and with certainty dissolve down all the blood into a thin, fluid, cadaverous water, that quickly passes, and sweats out, at all the emunctories of the body.

The use.

Hence we learn, in some measure, the sensible effects wrought upon the blood, by the admixture of certain known bodies, which being injected into the veins, produce the like effects in the living body, by bare mixture. But the same things, when taken at the mouth, often produce very different effects. And there are bodies, which being mixed in an incredibly small quantity, produce the greatest changes, without any sensible alteration of the fluids, as we see particularly in poisons. Therefore we must not always conclude, that the efficacy of mixture will be the same in the body, as out of it, whilst the blood being extravasated is contained in glasses. It also appears, that all mild things, rather than sharp ones, dilute and dissolve the animal fluids. Hence we see there can be no effervescences in the vital blood, contained in its proper vessels, and by no means such as can have a force equal to the removing of great obstacles, and producing very swift motions. *Paracelsus*, therefore, *Helmont*, *Descartes*, *Sylvius*,

Sylvius, and others, in vain took up this hypothesis, to explain the actions of the body. Hence appears the fatal error of those physicians, who, after having unjustly condemned acids, under the false notion of their coagulating the blood, by an argument wholly derived from milk; whilst *Hippocrates*, from a closer observation of nature, judged that vinegar was proper in inflammatory distempers, tho' the blood is thence rendered more dense. And we cannot safely pronounce concerning the effects of acids upon the blood, unless it be first distinctly explained what kind of acid is understood: the use of mineral acids is dangerous, but of vegetable acids more wholesome; and it frequently happens, that the things which really coagulate the blood are supposed to dissolve it.



PART

PART III.

Chemical Operations upon MINERALS.

I. PROCESSES upon SALTS.

PROCESS CXXVIII.

The examination of nitre.

IN the chemical treatment of minerals, we are first to begin upon salts; these being generally required in the preparations of other fossils. And because among fossil salts, nitre, in its origin, nearly approaches to animals and vegetables, this must first be treated on, as being a kind of dubious thing among the three, and appearing to proceed from putrefied animals (that do not use sea-salt) mix'd with alcali and lime; but of this we have sufficiently treated in the second part. It does not seem to be the *nitrum*, or *litrum* of the ancients.

1. Put nitre into a clean crucible, and fuse it with a gentle fire, without fulmination; it remains melted like pure water, without changing its nature, and scarce losing any thing by exhalation. It passes thro' the crucible, but does not grow alkaline, or become sharper; and when poured out, it presently becomes solid, and never when, thus melted, takes flame, nor ignites; whence it is falsely called an inflammable salt. And yet whilst it remains thus fused, if any combustible matter be thrown into it, it immediately takes flame, whence it came to be called inflammable; but when taken internally, it cools the body more than any other salt.

2. Put a solution of the purest nitre, made with water, into separate glass vessels, and pour successively to them different acids; and the liquors will be found to make no ebullition, nor to grow warm, opake, or troubled. To another parcel of the same pour pure oil of tartar *per deliquium*, whereupon the liquor will grow opake and muddy, and soon deposite a large sediment at the bottom; from whence the liquor being decanted, it will no longer grow troubled by the addition of fresh alcali: and nearly the same thing happens upon the addition of volatile alcali. And this is the true nature of nitre.

The use.

Hence it appears that nitre is neither alkaline, nor acid, nor of itself inflammable; but of all salts the easiest fused in the fire.

PROCESS

PROCESS CXXIX.

The refinement and crystallization of nitre.

1. **D**ISSOLVE common nitre in six times its quantity of boiling water, strain the hot lixivium quick, put it into a clean cylindrical vessel, and exhale it over a clear fire, to a pellicule; set it in a cool place, with clean sticks across the vessel: there will presently be formed long prismatic, hexagonal, transparent crystals. Collect these, and put them into an earthen colander, that the liquor may drain from them; afterwards dry the nitre in the open air.

2. Dissolve nitre in eight times its quantity of boiling water, filter the lixivium, then drop therein some pure oil of tartar; mix them well, then drop in more, and continue to do thus, till the liquor appears no more disturbed. Boil the lixivium for a single minute, strain it hot to make it perfectly clear; exhale to a pellicule; pour it out into a clean cylindrical vessel, with little sticks laid across, and let it stand in a quiet place: prismatic crystals, like the former, will thus be formed. No experiment shews, that any alcali here adheres to the crystals of nitre, which is thus made pure; nor does it appear that any method can afford it purer.

3. Let the lixivium, that remains after this first crystallization, be diluted with an equal quantity of fair water, then boiled for a moment, filtered hot, inspissated to a pellicule, and set in a cold place, as before; it will thus shoot into crystals of pure nitre, which are to be dried as above. The remaining lixivium being again treated in the same manner, and again set to crystallize, yields more of them. And now the remaining liquor, which is fat and sharp, will afford no more crystals, and dries with great difficulty; and this happens not only when alcali has been used in the refining, but also when nothing but pure nitre was added. This last remainder is a peculiar and very saline fluid, that long remains fixed in the fire.

The use.

1. By this means an excellent nitre is procured for medicinal use; being very light, of a particular bitterish taste; and when taken into the body, it easily dissolves therein, wonderfully cools and thins the blood, giving a florid colour thereto, and checking the inclinations to venery. It is changed in the body, not being unalterable therein like sea-salt, but turning into the human salt, as explained in our processes upon urine. If the moist, or solid parts of animals be salted with this nitre, they are thereby kept extremely red, and free from putrefaction; whence in all inflammatory distempers, attended with an inflammatory condensation of the blood, this salt proves excellently attenuating, and at the same time no way offends by any violent acrimony, nor proves prejudicial by its weight. It does not occasion thirst, and prevents the salt of the body from turning alkaline, and the oil from putrefying: and on this account it may properly be called an antiphlogistic salt.

2. Here we see an example of that operation usually called the crystallization of salts, which is a collection of saline principles of the same species, into particular glebes, or shoots, always of the same figure, and peculiar to each particular salt. This depuration depends upon that law of nature, whereby the parts of different salts being diluted in water, and brought to a certain proportion in respect of the water, begin to acquire a faculty of uniting their own particular parts together, more than of uniting with the water, or any other salts, whence they repel both the water and other salts. And thus those salts always begin to come first together, when several kinds are mixed, which require most water to keep them dissolved; for thus these associate first, and repel from them the other saline parts, that remain fluid in less water; so that if any salts could be resolved in one and the same proportion of water, it would be extremely difficult to separate and distinguish them; which is now easily and certainly performed. And thus nitre is perfectly separated from sea-salt, and sea-salt from salt of tartar. For when nitre is thoroughly purified from sea-salt by crystallization, it affords an acid spirit by distillation, which dissolves silver, but will not touch gold: whereas, if a little sea-salt remained with the nitre, it would afford an *aqua regia*, not an *aqua fortis*. The same nitre being dissolved in water, and purified with the addition of fixed alkali, does, by the bare crystallization, throw off all the alkali; for, in distillation, it is converted into an acid spirit, which would not be such, if any fixed alkali adhered to the nitre. Whence we may observe a wonderful attractive, and repelling power, in this action of crystallization.

3. If these crystals are well prepared, they always appear transparent, and of their own exact particular figure; and so long as they appear thus, they always consist of the salt and water united in a certain method and proportion. This appears from hence, that if these crystals be put into a clean glass, covered with an alembic-head, and heated by the fire, they yield a pure water; but at the same time presently grow white, opaque, and losing their figure, fall into a powder of no particular figure. But if this powder be again dissolved in water, inspissated, and crystallized, the same form and transparency return. Whence this ought to be considered by those who write about the figure of the saline principle. Nitre, thus purified, remains dry in the air, and does not easily run by the moisture thereof.

PROCESS CXXX.

Nitre changed to alkali, with tartar and fire.

TAKE six ounces of pure dry nitre, reduced to powder, and the same quantity of pure, dry, and pulverized cream of tartar; mix them together in a mortar, and again, dry the powder thoroughly; put an ounce of this powder into a clean and dry bell-metal mortar, first well heated, and apply thereto a little bit of burning coal: the whole mixture will thus instantly deflagrate, with a violent noise, scattering many sparks abroad, and dispersing a strong-smelling fume; and leaving behind a white
mass,

‘ mass, somewhat greenish in several parts. As soon as the deflagration is over, throw half an ounce of the same powder upon the burning mass, and this also will deflagrate as the former, but quicker, because of the greater heat. Continue thus, till the whole mass is deflagrated, and leaves behind a white, greenish, uniform mass, except a few small parts up and down, which have not sufficiently felt the fire. These, therefore, should be carefully separated from the rest of the mass; and hence it would be better if only a small quantity were deflagrated at once, because the fire would be thus more equably applied thereto.’

The use.

Hence it appears that nitre, which of itself is not inflammable, according to the hundred and twenty-eighth process, yet being mixed with tartar, which is oily, according to the fifty fifth, it immediately takes fire, with a violent agitation, like gunpowder, upon the application of a live-coal; and that the manifestly acid salt, made by a mixture of nitre and tartar, is at once by a single, sudden, inflaming action of the fire, turned into alcali, of which, a little before, there appeared no sign, either in the nitre or the tartar. Nor is there hitherto known any method so sudden, of producing a strong fixed alcali, from a mixture of salts that are not alkaline, but on the contrary giving manifest signs of a predominating acid. For the salt thus produced is a sharp, fixed, and strong alcali, in all its effects, and almost in every chemical, medicinal, and physical operation. It however differs somewhat from other fixed alcalies, as yielding, when oil of vitriol is poured upon it, a certain acid spirit, that plainly appears, by its scent, to be spirit of nitre; which shews that some true nitre still remains in this alcali, according to the hundred and thirty-fourth process, now soon to follow; but the quantity of this acid is small. We have here, therefore, an excellent method of expeditiously preparing a fixed alcali, whenever it is wanted; and this sudden change of nitre into alcali will not appear strange to him who knows that no nitre is obtained in *Europe*, without the assistance of fixed salt, which is found in the ashes of burnt wood. Lastly, the salt, thus prepared, readily runs in the air.

PROCESS CXXXI.

Nitre turned to an alcali with live-coals.

‘ **F**ILL a strong and large crucible with very dry powdered nitre, laid in light; set the crucible firm in the furnace, and surround it with burning coals at a distance, then gradually bring them nearer, that the crucible, with the nitre it contains, may be thus heated equably, to prevent bursting. When all is now thoroughly hot, apply as strong a fire as is necessary to make the nitre run like water; then take a little piece of wood-coal, thoroughly ignited, and put it gently into the melted nitre, now at rest. The coal (not the nitre) will thus instantly take flame with a hissing noise, and move over the whole surface of the melted nitre with

‘ a brisk motion, till it is consumed, and the flame extinguished, so as to leave the nitre melted, as before it was thrown in. Now throw in another bit of live-coal as before, and the same phenomena ensue; continue repeating the operation, till at length the nitre remains fixed with the same degree of fire, so as to flow no longer, nor give flame to the coal thrown in, which at length will always prove the case. This state may be known to approach, when the nitre begins to lose its fluidity, and the coal leaps briskly about, and sometimes flies out of the crucible: at this time, therefore, the fire should be a little increased. When the coal ceases to flame any longer, let all cool, and there will remain in the crucible a mass, with an hollow part on its top, where the last burning coal had rested: this mass is solid, ponderous, of a colour betwixt white and green, fiery, alkaline, and presently runs in the air; therefore, whilst yet very hot, let it be presently taken out by breaking the crucible, and put into a clean glass, to be carefully stopped.’

The use.

1. Here the eye perceives that nitre will not take flame with a burning coal; and that between the inflammable matter of the coal, and the melted nitre, there arises a great motion of impulse and repulse: for when the live-coal, that flew about in the crucible, is consumed, the nitre immediately remains without any visible motion, and does not appear on flame till, by the addition of a fresh coal, the same motion is renewed; and therefore the consumption of the coal is hastened by the melted nitre, whilst it would otherwise consume much slower; and this accelerating action of the fire, upon the combustible matter, seems to increase the deflagration; and, therefore, that the effect of nitre upon combustible bodies, by means of fire, is no more than this violent repulsive motion, whereby the coal, if somewhat large, is driven from the nitre with an explosive force; after which the whole nitre remains calm and at rest.

2. The ashes of the fixed vegetable coal, after the deflagration, here turn into a fixed alkali, that very easily relents in the air; but this alkali, here produced, is much larger than would be afforded by the burnt vegetable matter, and must also proceed from the changed nitre. This is another method of converting nitre into alkali: the alkali, thus produced, is very difficult to keep dry; but presently relents in the air, and runs into a strong fiery alkaline liquor, leaving a large quantity of ashes behind. But if the salt, as soon as prepared, be dissolved in rain-water, and directly strained, and the fæces remaining in the strainer be washed so long, in changes of water, till they retain no salt, they now become insipid, when dried. And if the several solutions be evaporated to the consistence of the oil of tartar *per deliquium*, a liquor like that will be obtained. And these pure ashes, being weighed, will shew how much of each remained after the deflagration; and consequently how much salt of the burnt vegetable-coal might contribute to the making of this alkali: and hence also may be known, how much the nitre contributed to its production. This preparation is commonly called *alcalized or fixed nitre*.

PROCESS

PROCESS CXXXII.

Sal prunelle from nitre.

1. TAKE nitre, purified according to the hundred and twenty-ninth process, melt it at the fire in a clean crucible, and as soon as melted, pour it out in cakes upon a clean marble, and keep them, under the title of *sal prunelle*, for medicinal use.
2. Dissolve this nitre in clear rain-water, wherein red poppy flowers have first been infused warm, so as to give a beautiful tincture, which is to be filtered; inspissate the solution, and let it shoot into crystals, in the common method: these being dried are another kind of *sal prunelle*, or crystal mineral, formerly held a secret, as an infallible antiphlogistic.
3. Melt four ounces of pure nitre in a clean crucible, and throw a scruple of the flowers of sulphur thereon, there will instantly arise a great flame, like lightening, which, when the sulphur is entirely consumed, directly goes out of itself. And this being three or four times repeated, and the nitre poured out into moulds, so as to form little cakes, is another medicated *sal prunelle*.

The use.

The nitre thus prepared entirely agrees, in virtue and use, with that of the hundred and twenty-ninth process; which I rather prefer, as the trouble of the present process seems unnecessary; and refined nitre every way answers the purpose. But hence we see that melted nitre, tho' perfectly at rest in the fire, has the same effect upon inflammable sulphur as it before had on the ignited coal; that is, to make it deflagrate quicker and stronger: and hence the discovery of gunpowder, which is prepared from nitre, sulphur, and coal. This present preparation has obtained the name of *sal prunelle* from the *Germans*, who observing that a certain kind of epidemical camp-fever, attended with a dangerous black quinsey, which they call *die braune*, was happily cured by the use of this powder; they thence called it by that name: and for the same reason they give the same appellation to the plant self-heal, or *prunella*; because this cures the same distemper. The salt, thus prepared, is never alkaline.

PROCESS CXXXIII.

Sal polychrestus.

1. MELT pure nitre in a crucible, and throw a little pure sulphur thereon, not exceeding a scruple at a time; it will deflagrate, as in the preceding process; continue throwing on the same quantity after each deflagration, till at length as much sulphur is used as there was nitre: towards the end of the operation, the sulphur thrown in does not flame so violently, nor so brightly as before. Keep the crucible still in the fire,

in

‘ in the state of ignition, for an hour; the salt will appear reddish up and
 ‘ down, but otherwise of a grey colour; if immediately after the deflagra-
 ‘ tion with an equal quantity of sulphur, the salt be taken out without any
 ‘ farther application of fire, it has always appeared to me, upon examination,
 ‘ to have perfectly the same efficacy as the former. 2. Or take equal parts
 ‘ of pure dry nitre, and flowers of sulphur, grind them to fine powder, and
 ‘ heat it carefully; then throw two scruples thereof at once into an ignited
 ‘ crucible, whilst it remains in the fire: a violent deflagration will immedi-
 ‘ ately arise; which being over, throw the like quantity to the remainder;
 ‘ and this will deflagrate as the former. Continue thus till all the powder
 ‘ is thrown in; there will now remain at the bottom of the crucible a salt
 ‘ extremely like the former. 3. Dissolve the salt, thus prepared, in five
 ‘ times its quantity of hot water, in a glass-vessel; strain it, whilst it is
 ‘ hot; inspissate it to driness; it will be of a white colour, of a bitterish sul-
 ‘ phureous warm taste, and of the same nature with the salt sometimes found
 ‘ in hot mineral waters; it is neither acid, nor alkali, but consisting of nitre,
 ‘ and some proportion of sulphur, changed by the fire.

The use.

Sulphur, therefore, which consists of the acid of vitriol and oil united together, has here the greatest part of its oil consumed in the flame with the nitre; and its acid part, now, perhaps, somewhat changed by the fire, along with some part of its oil, intimately mixed amongst the nitre, now also changed by the same, so as to produce a neutral fossil salt in the fire. Whence we see that nitre, which, when fired with a vegetable coal, turned into fixed alkali, is here, with sulphur, changed into a fixed salt, that is not alkaline, tho’ it had so long and so strongly been deflagrated with sulphur. Physicians, especially those of *Paris*, having thoroughly experienced the virtues of this salt, called it *polycbreftus*, because of its various effects, and proving successful in many different diseases. If taken upon an empty stomach, by a person in health, in the quantity of two drachms, diluted with twenty times its quantity of water, the person walking gently after it, and drinking four or six ounces of new whey, for three or four times, it sometimes proves gently vomiting, oftner purgative; but always diuretic and sudorific, so often as it is determined to operate that way, by heat, motion, and sudorifics. It cuts cold viscous phlegm, resolves in dense inflammations of the blood, opens the passages, corrects the bile when tending to putrefaction, excites it when languid, and stimulates it with gentleness and safety. Hence, being prudently given in chronical and acute distempers, it proves curative. It almost certainly cures inveterate tertians, without any danger of relapse, or without obstructing the *viscera*. It securely cures quartans, by gradually resolving the sluggish matter thereof; and therefore has deservedly obtained the name of the salt of many virtues. If a little sal-ammoniac be thrown into melted nitre, it takes fire: and if saturated by repeated addition, it affords a wonderful salt, that deserves to be examined, on account of its particular nature,

PROCESS

PROCESS CXXXIV.

Glauber's spirit of nitre.

PUT eighteen ounces of pure dry nitre, reduced to an impalpable powder, into a clean glass retort, and pour thereon six ounces of pure, and highly rectified oil of vitriol: immediately place the retort in a sand-furnace, and apply a large glass receiver; luting the juncture with a mixture of lime-clay and a little sand. There will presently arise a heat, and a red fume; apply a moderate fire, and the receiver will soon be full of red fumes, and a liquor begin to drop gradually. Increase the fire to the utmost that sand will give; and then let all spontaneously cool. As soon as the neck of the retort is a little cold, separate the receiver, and have at hand a strong dry glass, with a narrow neck, fitted with a slender funnel; pour the liquor into a bottle, thro' the funnel, under a chimney, to prevent the red fume from any way coming to the lungs, for it is sharp, fiery, incredibly volatile and diffusive; as soon as the spirit is in, exactly stop the mouth of the containing glass with a glass-stopper: in like manner, stop the receiver, and set it by for the same use; it will remain for many weeks filled, with a red vapour, in continual motion. The liquor, in the glass will appear of a gold-colour, with a red vapour always appearing in the empty part above, even for years, as I have found by experience: and if at any time opened, a volatile copious, red vapour immediately flies out. The operation is best performed in the cold winter-season.

The use.

Oil of vitriol can scarce touch nitre, but there immediately arises a violently acid, sharp, fiery, volatile spirit, that is perfectly nitrous, and has all the same effects as common *aqua fortis*, and with fixed alcali returns to true nitre again. It is impossible to obtain more spirit from this nitre, by the addition of less or more oil of vitriol, whatever degree of a sand-heat be used. All the nitre, therefore, is not changed from fixed to volatile, from solid to fluid, from mild to sharp, from white to red, from neutral to acid, and from unactive to a moveable restless liquor. This liquor is the true spirit of nitre, as appears by its smell, taste, colour, red fumes, effects, and its power of regenerating nitre again. It contains nothing of the oil of vitriol employed, as appears from certain experiments: the other part of the nitre, therefore, which is not rendered volatile by this operation, unites with the oil of vitriol, fixes therewith, and becomes a white dense salt, neither acid nor alkaline, but neutral, and of a new kind, somewhat resembling the *tartarum vitriolatum*. Upon considering this, some eminent chemists have supposed, that nitre, in its origin, was made of a fixed alkaline salt, and the proper spirit of nitre, such as is here produced; and mixed together to a perfect saturation. But as oil of vitriol is a much stronger acid than spirit of nitre; when that comes to be mixed with the nitre, they imagine that the fixed alkaline part of the nitre attracts the acid oil of vitriol, so that the two
here

here unite into a salt, consisting of the alcali of nitre, and the oil of vitriol, whilst the pure acid of the nitre, now set free, by the oil of vitriol, from the alcali, that detained it before, remains a pure, red, volatile acid, of its own peculiar nature. Hence they attribute this whole action to the bare separation of the parts pre-existing in this form before, and not produced afresh by the action of the fire. This explanation seems very plausible, and countenanced by other experiments; particularly, hereafter, in the hundred and thirty-sixth, the hundred and thirty-seventh, the hundred and forty-third, the hundred and forty-fifth, the hundred and forty-sixth, and the hundred and forty-seventh processes. But if we consider the origin of nitre from animals and fixed alcali, it seems difficult to find a principle in them; any way resembling such an acid spirit, as is here prepared; especially, since the most diligent enquirers into nature cannot find any perfect nitre, spontaneously generated. Certainly, there is no instance of any natural acid like that here obtained; we must therefore abide by our experiments, and beware of hasty conclusions. There is no known method, either of art or nature, for obtaining a stronger, or a purer spirit of nitre than this; whence we shall always use this spirit for the future in those operations that require it. *Glauber* was the first who discovered this art, which he held as a secret, and sold the production at an extraordinary price, but at length divulged the method; to him we are therefore obliged for so excellent an invention. And hence we have an intimation what numbers of new, useful, and excellent discoveries might be made, by applying one body to another, and afterwards working upon them with fire. The present experiment is one of the noblest that chemistry ever produced.

PROCESS CXXXV.

Glauber's dulcified spirit of nitre.

1. **P**UT into a tall bolt-head eight parts of pure alcohol, prepared without alcali, let fall into it only a few drops at once of *Glauber's* strong spirit of nitre; then leave off, and shake the two liquors well together, that they may perfectly mix; afterwards drop in more, shake as before, and thus proceed carefully, till an eighth part of the spirit of nitre be added, in proportion to the alcohol; observing after each time to shake the glass thoroughly. Afterwards digest the liquor for some time; and then distil it twice or thrice over in a retort: thus a true dulcified spirit of nitre will be obtained (a). 2. If common spirit of nitre, and common spirit of wine, were here used, they would not thus afford so noble and balsamic a spirit, on account of the water they each of them contain. 3. I have often experienced, and shewn the dangerous effects that may arise upon mixing large quantities of alcohol and strong spirit of nitre together; for if to two drachms of *Glauber's* spirit of nitre, contained in a bolt-head, there be at once added six or seven drachms of alcohol, there will arise a violent

(a) See *Hoffman. Observat. Physic. Chym.* p. 128.

heat,

heat, ebullition, and vapour; and all the liquor suddenly escape out of the glass, tho' it were ever so high, and this with great danger of suffocation, if it should touch the lungs; and in this manner I have lost both the liquors. The excellent Doctor *Slare* has more observations to the same purpose (a).

The use.

Upon thus mixing together alcohol and spirit of nitre, there immediately arises a fragrant smell, like that of southern-wood; there is also observed a high degree of effervescence betwixt this volatile acid and pure subtile oil, without the least interposition of an alcali. And yet the effervescence is almost fiery; so that if a lighted candle were applied to the vapour, the inside of the glass would appear on flame, and the whole instantly burst in a dangerous manner. The often these two liquors are digested, and distilled together, the more exactly they unite, and thus afford a perfectly acid and oily salt, which has an actual preservative, balsamic, detergent, dissolving virtue, and prevents the putrefaction of the bile. Being properly diluted, and prudently used, it presently gives a beautiful whiteness to the teeth; but if imprudently used, destroys them. It restores the appetite, if depraved by a mucous phlegm, or corrupt bile, or if the cause proceeds from a weakness of the stomach. It is a great carminative; it is recommended as a preservative against the stone, and even as a solvent for it. It was formerly the famous lithontriptic of *Sylvius*, held at so dear a price. It promotes sweat, provokes urine, allays thirst, corrects a fetid breath, and has particular virtues in the scurvy. It is conveniently taken upon an empty stomach, to twenty or thirty drops in wine, mead, or beer.

P R O C E S S CXXXVI.

The regeneration of nitre, by means of the hundred and thirtieth, hundred and thirty-first, and hundred and thirty-fourth processes.

1. TAKE an ounce of dry fixed nitre, made according to the hundred and thirtieth, or hundred and thirty-first process; dissolve it in eight times its quantity of fair water, and filter the solution. Pour the liquor hot into a clean, heated, large glass, with a narrow neck; drop thereto, successively, a few drops of *Glauber's* strong spirit of nitre: the falling in of each drop suddenly occasions a great effervescence; shake the glass so long as this continues, then drop in more, as before, and continue thus, till the effervescence begins to abate; after which add only a single drop at a time, and strongly shake the hot liquor. Proceed thus, carefully, till no more effervescence appears; the liquor will be transparent, and certain long, and crystalline shoots begin to form therein. It has no scent, the taste is somewhat bitterish, and perfectly nitrous. Dilute

(a) *Philos. Transact. Lowth. Abridg. vol. III. p. 358.*

‘ the liquor a little more, boil it for a moment, strain it hot, evaporate to a pellicule, and actual crystals of nitre will shoot. Strain the remaining liquor, inspissate, and crystallize as before; thus more true nitre will be obtained.

‘ 2. If any other pure fixed alcali, prepared from tartar or pot-ash, be used in this experiment, instead of fixed nitre, the success will be in every respect the same; and no difference be found in the nitre produced.’

The use.

The illustrious Mr. Boyle conceived so highly of this experiment, that he thought proper to write a treatise upon it; and truly it is one of the most capital discoveries in chemistry; as shewing how, from the strongest and most corrosive acid and alcali, immediately to produce, by a bare proportional mixture, a neutral, mild, cooling salt, in no respect corrosive. Here a highly odorous and volatile acid is, in an instant, attracted into a fixed alcali, with the loss of all its odour and volatility, so as to bear a fire of fusion, without any remaining volatility: whence we may easily understand the great attractive force there is betwixt acid and alcali. At the instant of this conflict, a quantity of elastic and highly expansive air arises, which is only generated in the action of the attraction, and ceases when that is over: whence air seems to be struck out of the bodies of the acid and alcali in the collision. Hence this action seems to be an attraction, not a repulsion, and perhaps the violent and sudden motion arises from the expulsion, and breaking out of the air, whilst the alcali and the acid are closely uniting. Here we see, likewise, a subtile liquid acid again forms a firm, solid, saline body with an alcali; and that the alcali, which would before run spontaneously in the air, and the acid of the nitre, scarcely by any other means to be rendered solid, afford a salt upon uniting, which, when dry, will remain firm in the air, and even acquires a solid form, or shoot into crystals in water. Here again, we see, that an alcali may be determined by an acid, into that kind of salt which afforded the acid; and, therefore, that alcali is indifferent to every acid, and capable of uniting with them all, tho’ always so as to regenerate the salt which afforded the acid. Hence alcali appears a kind of unimpregnated or female body, to be impregnated by an acid, which acts as the male with respect thereto, and generates its own kind, or preserves its species: and, therefore, the indifferent nature of alcali is determined by the acid. And hence, again, it appears, that the last principles of nitre may consist of any fixed alcali, saturated with the acid spirit of nitre; and, therefore, that the nature thereof, the figure, and other properties, may be owing to a conjunction of them both. But whether all nitre originally proceeded from this acid, before pre-existing of itself, and united with a fixed alcali, in like manner pre-existing by itself, I cannot say; and very much question. But that nitre may be made in this manner, and also that it may be procured from earth impregnated with the dissolved parts of animals, and the saline parts of vegetables, as also with quick-lime, I certainly know; and this is sufficient for me.

PROCESS

PROCESS CXXXVII.

Nitre regenerated in an unfixed state.

1. INTO a capacious glass, with a narrow neck, put three ounces of pure volatile alkaline salt, prepared according to the hundred and sixth process; dilute it with six times its quantity of fair water, and, when dissolved, drop in a quantity of pure spirit of nitre; an effervescence will rise like that of the preceding process. Continue in the same manner as there directed, till the point of saturation be exactly hit; soon after which, oblong, saline, prismatic, eight-sided crystals will shoot, exactly like nitre.
2. Again, dilute this compound liquor with twice its quantity of water, filter, exhale to a pellicule, over a gentle fire, and set the whole in a cold place, and nitrous crystals will be formed. Prosecute the operation till all the salt is shot, which will appear in the form of scentless crystals of nitre, and of the same cold, bitterish taste, which is peculiar to nitre. These crystals easily melt in the fire, but at the same time fly off, not remaining fixed like nitre; they make a flame with all inflammable matters, like true nitre; and with oil of vitriol afford a spirit, like true nitre. Hence they are true nitre, but semi-volatile.

The use.

This is an excellent experiment, and teaches the several particulars explained under the last process; to which we may add, that here, from two of the most odorous bodies there arises a perfectly inodorous salt; from two violent caustics, an exceeding cool and mild salt; from two very volatile bodies, a salt that is not volatile, except with a considerable heat. Here the volatile alkali, of itself indifferent, is, by a saturating acid, turned into a particular salt of the nature of the acid employed, which thus regenerates the body that produced it. Hence we see that the volatility of a salt depends upon the alkali contributing to its composition; which alkali, if fixed, the salt is fixed; if volatile, the salt is volatile: and that the nature of the salt produced depends upon the acid mixed therein. And hence we have the method of procuring a volatile nitre; the discovery whereof has exercised the labour and industry of the chemists in all ages. The virtues of the semi-volatile nitre, thus prepared, as far as I could observe, are of the same kind with those of common nitre, or the fixed regenerated kind, tho' more gentle, and differ only as the virtues of sea-salt differ from those of sal-ammoniac.

PROCESS CXXXVIII.

Glauber's alcabest.

- PUT the alkaline salt, prepared according to the hundred and thirty-first process, in a glazed dish, and expose it to the open air, in a cold

The Practice of CHEMISTRY.

‘ cold quiet place, free from dust ; it will soon begin to run ; pour off
 ‘ what is dissolved into a clean glass. Again expose the remainder to the
 ‘ open air, and repeat the operation, till the whole salt is run into a liquor.
 ‘ Much ashes will remain behind ; but the liquor, when strained, becomes
 ‘ clear, alkaline, and thick, like oil of tartar *per deliquium*.’

The use.

This is that famous liquor of the chemists, boasted as so great a secret by its inventor *Glauber*, who put it off for the true alcahest : but secrets, once revealed, are slighted ; and this seems to be the case here. By all the experiments I have made, I could never discover any thing particular, and which I did not also find in oil of tartar *per deliquium*, in whatever case I applied it ; but *Glauber's* alcahest is prepared with more difficulty, obtained in less quantity, and comes dearer : and hence, perhaps, it pleases better.

PROCESS CXXXIX.

Nitrum nitratum.

‘ **T**O eight ounces of the lixivium of pure nitre, put thirty drops of
 ‘ the strongest spirit of nitre ; evaporate to a pellicule, and crystallize
 ‘ after the common manner : perfect nitrous crystals will be thus obtained,
 ‘ but of an acid taste.

The use.

This process serves to shew how certain salts may be united with the acids themselves afford, into the form of a compound salt. And by adding more, or less of the spirit, the salt may be made more or less acid ; but the more acid it is made, with the more difficulty it afterward dries, and keeps dry ; being thus always apt to run in the air. The nitre, thus prepared, is advantageously used in burning fevers, attended with a dry, foul tongue, and thirst.

PROCESS CXL.

Vegetating nitre.

‘ **I**F in the preparation of *Glauber's* spirit of nitre, according to the hun-
 ‘ dred and thirty-fourth process, there are taken four parts of nitre,
 ‘ and one of oil of vitriol, and after all the spirit is entirely driven off,
 ‘ the white salt, remaining perfectly dry in the retort, be left in the open
 ‘ air, its surface will soon begin to be covered with a thick long down, as if
 ‘ it grew ; which phenomenon I do not remember to have observed in other
 ‘ salts. But if the salt be dissolved in water, strained, and evaporated to
 ‘ dryness, in a cylindrical glass, then kept exposed to the open air, its upper
 ‘ surface will often appear thick-set, with a kind of actual little branching
 ‘ plants ;

plants; all which dissolve away upon the application of heat, so as to leave the surface even; but upon exposing the vessel to the open air, in a quiet place, they have grown up as before: thus several times exhibiting the resuscitation of plants, as it were from their own ashes, of which some of the chemists have formed so many fables; and I have sometimes suspected the thing might, perhaps, be done by this means.

The use.

This curious experiment shews that the great disposition which nitre has to crystallize, affords an opportunity of imagining a kind of artificial vegetation, such as some over credulous artists have feigned, but never, I conceive, exhibited, under the title of vegetable resuscitation.

PROCESS CXXI.

Spirit of nitre with bole.

1. TAKE a pound and half of purified nitre, reduced to powder, and four pounds and an half of common red bole, mix them well together, put the mixture into an earthen long-neck, so as not to rise into the neck thereof; as the long-neck lies horizontal in the furnace, after the manner described in our chapter of furnaces, let two of these long-necks be used at once, and lute on their receivers (a); apply a gentle fire at first to warm the matters, and increase it a little every quarter of an hour, till, by degrees, the furnace and vessels become thoroughly hot. A moist vapour will now begin to come into the receiver; increase the fire so far, by degrees, in the space of half an hour, till the vapour comes over reddish; and gradually raise the heat till the vapour comes over perfectly red. Continue thus for three hours; at length raise the fire so high, till the long-necks grow red hot, so that the ignited matter may, in the long-necks, be perceived thro' the glass receivers; and keep the fire up to this height for two hours; then let all cool, and as soon as the necks of the long-necks are cooled, take off the receivers, with care to avoid the fume; pour the distilled liquor, thro' a funnel, into a glass-vessel, which, being exactly fitted with a glass-stopper, is to be set in a cold place. This will be a very strong, acid, sharp, and caustic spirit of nitre, exhaling very red fumes, like Glauber's spirit of nitre, but is never so strong. When the distillation has been well performed, I have had of this spirit nine sixteenths, or one half and a sixteenth in respect of the nitre employed.

2. The bole, remaining behind, still retains a taste of the nitre. I have boiled the whole of it in a large proportion of water, strained the hot liquor, and repeated the boiling with fresh water, till it would fetch out nothing more; then boiling all the strained lixiviums, which were now

(a) For fuller instructions relating to the furnace and apparatus of the vessels here required, see the chapter of furnaces and process 144.

The Practice of CHEMISTRY.

clear, and of a nitrous taste, I evaporated them to a small quantity, of the thickness of milk: it had a taste not very sharp, but lixivious, as if somewhat alkaline: and examining it, by putting acids thereto, I found it in some measure alkaline, a little changed from the former nature of nitre, and yet not true alkali.

3. Great care is to be taken in this operation, that the coals thrown into the furnace, during the distillation, are first thoroughly heated, otherwise they would break the long-necks by the coldness, suddenly driven out of them by the fire. Hence care also should be taken upon opening the door of the furnace to feed the fire, lest the cold air, entering in too suddenly, should crack the vessels; and be cautious, likewise, lest upon opening the door of the furnace, the flame should violently burst out into the face of the operator; or be received, with the air, into the lungs.

4. Pure nitre, by itself, in a glass-retort, and a sand heat, melts long before the glass; and when heated so as to melt, it receives no more heat by increasing the fire; and tho' long kept in this state, it affords no acid spirit, but remains fixed without considerably exhaling. And if long detained thus in a *Hessian* retort, and the fire be violent, the salt, at length, passes thro' the pores of the earthen vessel, without sending any acid spirit into the receiver; but is at length almost lost, by transuding thro' the vessel.

5. Nitre mixed with thrice its quantity of bole, brick, or tobacco-pipe-clay, reduced to powder, then put into a crucible, and set in the fire, does not melt, but fume, affords an acid vapour, and thus, in a short time, evaporate its greatest part into the air.

The use.

1. Hence it is plain, that the fire acting upon nitre, whilst it is prevented from melting, by the interposition of thrice its quantity of a matter that will not flow in the fire, has a very different effect, and heats much more strongly than when the salt flows in the fire, and, therefore, cannot be farther changed thereby. The change is effected by rendering a fixed substance volatile, a mild one sharp, changing a solid into a fluid, and a neutral body into a violent acid; all which can only be obtained by preventing the fusion of the salt, as, in the hundred thirty-fourth process, we did by means of oil of vitriol in a sand-heat. But whether in the spirit, thus prepared, there is not also some liquor proceeding from the bole, has been much questioned; chiefly because the bole, once employed in this operation, is said to be incapable of serving again; for that the spirit of nitre cannot hence be obtained. But certainly, the spirit of nitre prepared with the oil of vitriol, and that with the calx of vitriol, under the name of *aqua fortis*, and that with calcined alum, are alike to this, almost without the least difference; and yet no bole was employed in their production. Let the experiments, therefore, on each side of the question, be collected: a longer time will shew what a short one cannot.

2. Again, some discerning chemists among the moderns suppose nitre to be made up of alkali, and a particular nitrous acid, as we explained under the

the hundred and thirty-fourth, hundred and thirty-sixth, and hundred and thirty-seventh processes. The incomparable Mr. *Homburg* has, by a laborious experiment, and a subtle calculation, here determined the proportion of the alcali to the acid, to be as four hundred and eighty to a hundred and eighty three (a). But here, by distillation, nine sixteenths of acid are obtained, in respect of the nitre, and yet scarce any alcali is obtained from the remainder; whence it certainly appears that this acid proceeds from the nitre, as changed by the fire, and not by a separation of the acid and the alcali, pre-existing in the compound before the operation: so that the wonderful action of the fire here performs what is otherwise effected by the oil of vitriol. Since, therefore, true nitre is never found spontaneous in nature, and its spirit never without the assistance of oil of vitriol or fire, whilst the salt is prevented from melting; we conceive that the acid spirit of nitre nowhere existed in nature, before the discovery of the method of procuring nitre, and drawing a spirit from it; so far we mean as can be known from chemical experiments. Thus it was impossible both for art and nature to make gunpowder before the discovery of nitre, tho' even all other natural things were known, except nitre alone (b).

3. But when the red colcothar of vitriol, or calcined alum, is mixed with nitre in a certain proportion, so as to hinder it from melting in the fire, and, consequently, fit it to sustain a greater heat; it thus also affords an acid spirit in red fumes, in every respect resembling the true spirit of nitre of the present process, and in a large quantity. We are here to consider that the colcothar, and burnt alum, conceal a large quantity of a very strong acid, called oil of vitriol, or spirit of alum; and these acids, being actuated by the fire, enter the nitre, separate its spirit, substitute themselves in its place, and thus leave for a remainder a *caput mortuum*, containing that called the *panacea duplicata*, which is considerably like the salt produced in the making of *Glauber's* spirit of nitre: and this is the origin of all the *aqua fortis*, whose production entirely depends upon the reason above assigned, in the hundred and thirty-fourth process. This transmigration of saline acid spirits is a wonderful operation, whilst one of them possessing the place of another, drives the former out, and thus appears to produce unexpected transmutations. And by what we can hitherto learn, oil of sulphur made by the bell, and oil of alum, are perfectly the same acid; having all of them this property, that they separate all the other known acids from the bodies that hold them, render them perfectly volatile, possess the places thereof, and driving out the former acid spirits, form with the remainder a new body, of its own particular nature, according to that of this stronger acid. *Aqua fortis* is a mere spirit of nitre; colcothar can, by no violence of fire, tho' ever so long continued, be deprived of all its acid: hence the *caput mor-*

(a) Here seems to be no allowance made for the aqueous part, which holds the acid salt dissolved. This aqueous part is hereafter said to be as 60 to 19 of the true acid. See process 148. *ad fin.*

(b) This subject, as to the generation of nitre, may receive considerable light from *Strubb's* answer to *Henshaw's History of nitre*; and the younger *Lemery's* two papers upon the origin of nitre, in the *French Memoirs*.

The Practice of CHEMISTRY.

trum of vitriol and alum abound with a strong acid, which the fire cannot drive over: this acid is attracted by the other part of the nitre, which cannot be converted into acid, and uniting with this part, by the force of the fire, makes a new kind of salt, and sends over all the volatile acid spirit in the form of *aqua fortis*. But they who promise by the art of chemistry to convert the whole body of nitre, by distillation, into the spirit of nitre, by a true change of the whole, so as from a pound of nitre to procure a pound of spirit, assert a thing which to me seems perfectly impossible, and contrary to the nature of the art. I have made various experiments to assure me of this truth.

4. The spirit of nitre of the present process, *Glauber's* spirit of nitre, and the common *aqua fortis* well prepared, afford a nitrous acid, distinguished by its red fumes from all other acids, and always discovers itself by means of these fumes, and its particular odour. When mixed with fixed alkali, they regenerate a true nitre; they dissolve silver, and have all the other effects mentioned of them in our chapter of menstrua.

PROCESS CXLII.

The depuration and crystallization of sea-salt.

• **D**ISSOLVE common sea-salt in six times its quantity of rain-water; strain the solution hot thro' a close linen bag, so often as to render it perfectly limpid; then exhale away in a glass-vessel one sixth part of the water; set the remainder in a quiet, cold place for three days, in a vessel covered, to keep out the dust; if it deposits any fæces, pour off the liquor from them by gently inclining the vessel; if it deposits none, the liquor was perfect, and may now be evaporated to a pellicule: again set it in a cold quiet place, for twenty-four hours, during which time it will shoot into cubical crystals. Carefully pour off the liquor remaining after crystallization, dry the salt with a gentle heat, and keep it separate: this is the salt that I commonly employ for chemical uses. Let the remaining solution be again evaporated to a pellicule, and set to shoot as before. By thus continuing to repeat the operation, the liquor will at last become thick, unctuous, austere, and hard to dry, and scarce afford any crystals. If the salt, thus purified, be decrepitated in the fire, and afterwards fused with a strong heat, then poured out upon a dry marble, it resolves in the air, and deposits earthy fæces; from which the liquor being carefully separated, then inspissated, calcined, poured out, and suffered to run in the air; the operation being thus repeated, the salt at length vanishes into the air, as a very ancient chemical writer has truly observed.

The use.

What was said of nitre, in the hundred and twenty-ninth process, is farther confirmed by the present experiment. There is only one method of crystal-

crystallization, for procuring salts pure and simple, whilst their innate virtue, when the salts are diluted with a certain proportion of water, unites the similar parts together, and separates the dissimilar; and the water, being attracted more by one salt than another, causes one to separate from the water, sooner than another. And unless salts be thus previously depurated, it is in vain to expect they should afford pure spirits, which are necessary to certain operations. If any sea-salt were in nitre, the nitre, upon distillation, would afford not an *aqua fortis*, but an *aqua regia*; and the same holds true of sea-salt, if any nitre be mixed among it. The salt, thus obtained, is such a dissolvent of gold, that without its addition, gold can no otherwise be dissolved, except by fusing with metals. This salt is a wonderful preservative, by means whereof all the parts of animals and vegetables are kept from putrefaction.

PROCESS CXLI.

Glauber's spirit of sea-salt.

1. **T**O three parts of sea-salt, prepared as in the preceding process, and put into a glass-retort, pour one part of the strongest oil of vitriol; at the instant they mix, a volatile white vapour rises out, which is to be carefully avoided, as being suffocating, and capable, if but once drawn in with the breath, to stop the action of the lungs irremediably. Directly apply a large and cold glass-receiver, lute the juncture, apply a very small quantity of fire at first, for a wild spirit will long continue to come over, so furiously as to blow thro' the luting, or break the vessel; so that the fire must be kept gentle, for three or four hours; then encrease it a little, and a less volatile liquor will come over. After eight hours have been employed upon the operation, urge the fire till the iron pot becomes ignited, and no more liquor rises; then let all cool, and when the neck of the retort is no longer hot, take off the receiver; the liquor will fume: and beware of receiving it in with the breath. Pour it into a glass, well-fitted with a glass-stopper, and set it in a cold place; otherwise the glass often bursts, by means of the motion of the vapour. If thus kept for years, a white suffocating vapour immediately breaks out upon opening of the vessel; but if the spirit thus produced be carefully distilled in a glass-body, under a chimney, into a receiver, the volatile spirit will come over, whilst there remains at the bottom a more fixed liquor, of a colour betwixt a yellow and a green. This liquor remains quiet without exhaling, but that which comes over into the receiver has a violent suffocating volatility, and may be kept apart as a pure volatile spirit of salt in a close vessel.

2. To three parts of purified and dry sea-salt, put into a retort, add two parts of clean rain-water, and one part of the strongest oil of vitriol. Let the oil of vitriol fall in by slow drops, to prevent bursting the vessel, by the sudden heat that would rise from mixing in the whole at once. The mixture will grow hot; place the retort in a sand furnace, and apply

a capacious receiver; distil gently for the first four hours, while the water comes over slowly; otherwise, if made to rise briskly, it always cracks the receiver. After this, increase the fire gradually; the spirit of sea-salt will come over, which is then known to rise, when the liquor runs in spiral veins. Now raise the fire, and gradually urge it, till at length the iron-pot grows of a red heat, and no more liquor comes over; at which time the spirit will not fume. Then suffering all to cool, pour out the spirit, which is now neither suffocating, nor smoking. If this be distilled again with a gentle fire, in a glass-body, there will come over a limpid, ungratefully acid water, of excellent internal use, being mixed with juleps, in such distempers as require it; an excellent fat spirit will remain in the bottom, of a colour betwixt green and yellow.

3. In both cases there will be left behind a very white and fixed salt, that can only be fused with a violent fire; this salt will come to be more particularly considered, under the hundred and forty-fifth process.

The use.

It seems surprising, that oil of vitriol should raise so volatile a spirit, by being barely poured upon so fixed a salt as sea-salt; which spirit is again fixed by adding fair water to it, and is not generated when the oil of vitriol is mixed with a strong solution of sea-salt for distillation; or again, when the oil of vitriol is diluted with water, and added to the sea-salt: in which three ways this surprising and suffocating volatility is fixed, and rendered unhurtful: but when the spirit, thus fixed and rendered wholesom, is urged with the heat of a hundred degrees, it lets go its water, and remains rich, very fat, thick, gratefully acid, fragrant, and of a greenish colour, and as perfect as can be any way obtained. But here again are certain limits, for only one certain part of the salt is thus converted into acid spirit; whilst the other remains fixed with the oil of vitriol. I could scarce gain more than a third part of pure spirit, separate from the water, in proportion to the salt. This spirit has some properties in common with other acids, and some particular. It is particularly grateful to the stomach, excites the appetite, attenuates mucous humours, resists putrefaction, and corrects the bile, when either too acrimonious, large in quantity, or corrupted. It is of excellent use in curing gangrenes of the gums, mouth, or tongue; it prevents the generation of the stone, and, according to *Helmont*, helps to dissolve it; it is serviceable in the strangury attending old-age. If the strongest spirit of salt be mixed with thrice its weight of alcohol, and the two be thoroughly united together, by two or three distillations, they make a volatile, oily, acid, fragrant and balsamic spirit of great virtue. This acid spirit dissolves gold, when very strong, or rendered more noble by being several times drawn over from sea-salt: in short, this liquor exceeds all that can be said of it: and this is another highly useful experiment, which we owe to the industry of *Glauber*.

PROCESS

PROCESS CXLIV.

Spirit of sea-salt with bole.

1. TAKE six pounds of pure dry sea-salt, put it into two earthen long-necks, each of them containing three pounds of salt; put the long-necks into the fire, and cover them with tiles to prevent any thing falling in. Let the fire be placed around them, at some distance first, and afterwards gradually nearer, and at length up to their sides: the salt will for a long time continue to crackle strongly; but this decrepitation at length ceases, when both the long-necks are thoroughly ignited. When the fire is burnt down, the salt is found white, pulverized, and will not crackle, when thrown into the fire. It loses always one fourth in the decrepitation, but seems otherwise unchanged; tho' it would easily grow moist in the air. It is now fit for distillation; wherein had it been employed without decrepitation, the action of the fire would have made it leap into the receiver, so as to disturb the operation, and sometimes to burst the vessels: but its wild crackling spirit being drawn out by calcination, it will afterwards calmly endure the fire.

2. Take three pounds of this salt, as soon as it is decrepitated, grind it in a large hot mortar, and presently mix therewith ten pounds of common red bole; divide the mixture into two parts, and charge two long-necks therewith, so that the matter may not come into the mouths of the vessels, as they lye horizontally in the furnace. Then fit them into the reverberatory; building up the open side of the furnace with bricks and mortar, so as to leave the necks of the vessels to come thro' the wall; apply adopters, and large receivers, in the same manner as in the hundred and forty-first process. Apply a gentle fire, increased by degrees for twenty-four hours, that all may become thoroughly hot and dry. Then light up a strong fire in the morning; a copious white vapour will come over, like white clouds, into the receivers; and dewy drops appear in the internal surface thereof. Keep the fire thus for two or three hours, then increase it, upon which the receivers usually become clearer, and the spirit runs in unctuous veins. And now the fire may be increased to the utmost degree, and continued thus for six or eight hours, that the vessels may be thoroughly ignited. When no more spirit comes over, leave off; let all cool; carefully take away the receivers, and empty the pure liquor: it will be acid, gratefully fragrant, of a green colour, and in the quantity of about six ounces from a pound: the bole remains saline. I have boiled it in water, filtered, and inspissated the lixivium, and thereby procured a large quantity of a yellow, saline, styptic salt, that was not alkaline, but appeared a new kind of salt. And this has generally been my success; whence I wonder *Beguinus*, and others, should write, that they could convert the whole quantity of salt into excellent spirit of salt: for my own part, I never could, with the utmost care and caution, in the most exact manner, and with the strongest fire, long continued, obtain above half the quantity; unless there had chanced to be any moisture ad-

hering to the salt, or the bole. This distillation of sea-salt requires a stronger fire than that of nitre.

The use.

This spirit shews, that a certain part, but not the whole of the salt, is here converted into acid, by means of the fire and the bole. In this distillation, towards the end, a yellowish matter inclining to white, always fixes to the upper part of the receiver, and has a sweetish, styptic, saline taste; and I have found this in greater plenty, when the operation was performed with brick-dust, instead of bole: it seems to proceed from the salt and fat earth mixed together. The salt obtained from the *caput mortuum* is highly commended by *Helmont*, for the preparation of *Butler's stone*; and the spirit is recommended for the same purposes, as that of the preceding process, where the particulars, relating to this, are already considered.

PROCESS CXLV.

Glauber's sal mirabile.

TAKE the white, saline, fix'd salt remaining at the bottom of the retort in the preparation of *Glauber's spirit of sea-salt*, to be got out by breaking the glass; bruise it, melt it in a crucible at the fire, with care to prevent any coals falling in, and afterwards dilute it with common water. Or else dissolve the salt, as it remains in the retort, by pouring hot water to it; strain the lixivium hot, evaporate it to a pellicule, and set it in a quiet cold place; it usually coagulates into a mass like ice, or if it remains somewhat fluid, it turns solid upon being poured into another vessel. If the salt be dissolved in six times its quantity of hot water, then thickened again, and set by in a large glass, it shoots into beautiful crystals, of a particular figure, considerably large, that remain solid, and do not run in the air.

The use.

The famous inventor of this salt justly called it by the name of wonderful; not only on account of its being new, but of the surprising effects it produces. I know some chemists, that are fond of systems, pretend that no more than a true *tartarum vitriolatum* is here produced, which was long known before the time of *Glauber*. But *tartarum vitriolatum* has not the properties which are found in this salt, either in respect of figure, taste, effects, or any thing else: for if this salt be properly prepared, reduced to powder, and mixed with thrice its weight of vinegar, beer, wine, or water, and set apart, it freezes them. When melted in a crucible, if a fourth part of antimony be thrown to it, by a piece at a time, it wonderfully resolves it; and has many other effects, as to which *Glauber*, *Boyle*, *Becher*, and *Stahl* deserve to be consulted: all of them, men of the utmost penetration, in giving light to the more abstruse parts of chemistry; to whom we must also add the great *Homburg*. In surgery, this salt is of excellent use against putrefactions and gangrenes; it is also of use, when internally

nally taken; by gently stimulating, resolving, purging, and promoting of urine.

PROCESS CXLVI.

Sea-salt regenerated.

DILUTE four ounces of oil of tartar *per deliquium*, with thrice its weight of fair water; put them into a tall and large glass-body, with a narrow mouth, and heat the liquor strongly. Then, by means of a funnel, let fall into it, by a drop at a time, *Glauber's spirit of salt*, or that prepared with bole; a great effervescence will rise. When this is over, shake the glass, and mix all well together; then drop in more spirit, and mix as before, till the alcali is perfectly saturated with the acid. Now let the liquor rest, and gently pour it from its faeces into a filter; evaporate to a pellicule, set it in a cold quiet place, and perfect crystals of sea-salt will be obtained. Treat the remaining liquor in the same manner, after the first crystallization is over, and this will afford the same salt, which will be fixed in the fire, and have all the other properties of native sea-salt.

The use.

The vegetable alcali, which indifferently receives any acid, is here determined by the acid of sea-salt; and being saturated therewith, assumes the nature of that salt: and if this be compared with the hundred and thirty-sixth process, exhibiting the regeneration of nitre, it seems greatly to strengthen the doctrine of acids, alcali, and compound salts.

PROCESS CXLVII.

The regeneration of sal-ammoniac.

TAKE four ounces of the alkaline spirit of sal-ammoniac; dilute it with thrice its weight of pure cold water, in a tall capacious glass-body, with a narrow mouth; let fall into it, by drops, thro' a funnel, to direct it into the liquor, the strong spirit of sea-salt, prepared in either way above-mentioned; there arises a great effervescence: continue to drop in the spirit, till the point of saturation be perfectly hit; but in this respect, great caution is required; because, if the acid prevails, more than is requisite to a perfect saturation, it remains united to the salt: whereas, if the acid abounded in the fix'd salt of the preceding process, it may again be driven out by fire; but if this were attempted in the present case, both the acid and the salt, as not being here fixed, would evaporate together. If therefore the saturation be perfect, the liquor will be limpid, scentless, and of the particular taste of sal-ammoniac; and tho' boiled over the fire, affords no saline exhalation. Strain the liquor, evaporate to a pellicule, set it by, and there will shoot a fine woolly salt, perfectly

to *fecit* after the same manner as in the lixivium of sal-ammoniac thus treated. If the liquor were to be inspissated, till a dry mass remained at the bottom, it would be a white salt, in every respect ammoniacal; and may, by a proper fire, be raised into the true flowers of sal-ammoniac.

The use.

The volatile alkali of animal and vegetable substances, which, of itself, indifferently receives all acids, is here determined, by the acid of sea-salt, into a semi-volatile sea-salt. Hence the rule appears to receive confirmation, that acids determine alkalies into their own nature; whilst the alkali, either gives fixedness or volatility, according as itself is fixed or volatile. And, therefore, as a large quantity of volatile alkali, is continually generated from putrefied animals and vegetables; if there was in nature a spirit of sea-salt floating about in different places, sal-ammoniac would, in these places, be continually produced: and the same spirit meeting with a fixed alkali, produced from the ashes of vegetables, would immediately afford a true fixed sea-salt. But tho' it is easy to manifest these fixed alkalies by experiments, yet it is very difficult to shew the existence of such acids in nature; unless we had the secret of Mr. Boyle, who declares, that by a secret and long continued digestion, sea-salt may be so disposed as to part with its acid spirit by a gentle heat, before its water; and this without any addition (a).

PROCESS CXLVIII.

Tartarum vitriolatum.

1. TAKE three ounces of pure oil of vitriol, dilute it with thrice the quantity of warm water, in a tall capacious glass-body with a narrow neck; add to it, drop by drop, a quantity of oil of tartar *per deliquium*, till the point of saturation is perfectly obtained: otherwise a pernicious acrimony either acid or alkaline remains. In this experiment a violent effervescence will arise; and a white salt begin to appear at the bottom, long before the saturation is completed. After this point is found, shake the vessel for a considerable time, and taste the liquor; if it tastes neither acid nor alkaline, take a little thereof, and heat it, divide it into two parts, and to one, add a drop of oil of vitriol, and to the other a drop of oil of tartar *per deliquium*, and if no effervescence appears in either, the point of saturation, here so requisite for medicinal use, is exactly hit. If any effervescence arise upon the addition of the acid, the alkali prevails; and if the alkali causes any effervescence, the acid prevails; but when the equilibrium is obtained, let the liquor be entirely dissolved by the addition of hot water, so that all the salt may be taken up. Let the liquor be strained while it is hot, evaporated to a pellicule, and crystallized. A white salt will be obtained, of a neutral taste, that requires a large proportion of

(a) In his treatise of *Mechanical Qualities*.

water to dissolve it: what remains cannot be crystallized; as happens in the case of nitre, sea-salt, and almost every other salt.

2. Some eminent chemists, among whom we reckon *Tachenius*, imagine that the oil of vitriol, after having suffered so great a fire, carries up with it some volatilized metallic part, that gives a noxious quality to this salt, not to be easily destroyed; hence they endeavoured to obtain this acid native and simple, without fire, and join it with fixed alkali of tartar. They, therefore, dissolved vitriol in water, so as to make a dilute and pure liquor, to which, when filtered, they added oil of tartar *per deliquium*, drop by drop; upon which the liquor grows turbid, and the iron, in form of yellow oaker, falls to the bottom: they carefully proceed thus, till no more precipitate is obtained, upon addition of the alkali. This point they carefully observe, and set by the mixture, till all the metallic faces are precipitated, then filter the pure liquor, inspissate, and crystallize as before. Thus a *tartarum vitriolatum* is obtained without fire; and as they seem to imagine, without any suspicion of a sharp corrosive virtue. And if there be no blue, or green colour remaining in the liquor, or the salt prepared from it, the preparation will be good; but otherwise it will retain something of copper, and prove malignant.

3. When by the like means, a salt is prepared with any pure volatile alkali, and oil of vitriol, either alone or diluted with water, a like, but a semi-volatile and more penetrating salt is obtained; whereas the former is wonderfully fixed. This salt, in whatever manner prepared, appears considerably ponderous and solid; and yet at the same time is mild and opening.

The use.

The virtue of this salt is esteemed highly opening, if taken upon an empty stomach, diluted with broth or whey, and assisted with the exercise of the body; for thus by attenuating, resisting putrefaction, and stimulating, it opens the obstructed *viscera*, so as to have acquired the name of the universal digestive: but *Tachenius* calls it an unmetallic vitriol. From the hundred and thirty-sixth, hundred and thirty-seventh, and three last processes, it appears, that the most corrosive alkalies and acids grow perfectly mild upon mixing together. Whence we learn that two poisons, as they would prove, if taken separate, may be rendered innocent, if drank mixed together; or even that one may be corrected by taking the other soon after. Hence also we see that water may lie wonderfully concealed in salts, and at length be set free from them; for the acid spirit of nitre contains sixty parts of water, to nineteen of true acid; spirit of salt holds fifty-two parts of water, to thirteen of acid; and oil of vitriol sixty of water, to thirty-seven of acid; even supposing all these liquors highly rectified: so large a quantity, therefore, lay concealed in decrepitated sea-salt. And hence we learn that there are but very few simple fossil acids; as the acid of alum, vitriol, and sulphur is the same; *aqua fortis*, and spirit of nitre have no difference; and the spirit of sea-salt, salt-springs, and sal-gem are all the same.

II.

PROCESSES upon SULPHURS.

PROCESS CXLIX.

The examination of sulphur.

PERFECT sulphur is found in the mines, under very different forms; sometimes smooth and yellow, sometimes yellow and almost transparent like amber, sometimes red and almost transparent, like ruby, but more frequently of an opaque grey colour. Any of these sorts being put into a crucible, easily melt in the fire, and so long appear transparently red; but when cold, they again become opaque. Sulphur, as soon as melted, readily takes flame upon the admission of the external air, and burns blue; the vapour whereof, being received with the breath into the lungs, proves suffocating to all animals. It entirely burns away, or scarce leaves any fæces behind: if kept melting in the fire without burning, it discharges a strong smelling, acid, but not suffocating vapour; as soon as melted, some part of it goes into the air; and if long kept fused, without burning, it all of it gradually becomes volatile, and vanishes. When cold, it is extremely brittle; and when melted by heat, it seems viscous like pitch; and in neither form will mix with water. It will never dissolve in alcohol alone; if its powder be mixed with any acids or alkali, it gives not the least signs of ebullition, or effervescence; so that it has not thus the effect of an acid or an alkali. If taken crude into the body, by small doses frequently repeated, it wonderfully cleanses the first passages, at length purges strongly, and then effectually cures certain cutaneous diseases, and such as proceed from worms, or mercurial fumes.

The use.

Hence the nature of sulphur may be in some measure understood, as found naturally in the earth. And hence it appears why the chemists have called it the rosin of the earth: for excepting that it does not dissolve in spirit of wine and alcohol, in other respects it approaches to rosin.

PROCESS CL.

The flowers of sulphur.

1. TAKE six ounces of common sulphur, put it into a body of *Hessian* earth, apply a capacious glass-head, close the junctures with

‘ a mixture of equal parts of clay and ashes, wrought up with water; set
‘ it in a sand-furnace, so that the same may almost touch the lower rim of
‘ the glass-head. Let the pipe of the head, and likewise the body itself,
‘ incline a little downwards, that the moisture may run into the receiver,
‘ fixed for the purpose. Make a gradual fire, and continue it till the head
‘ begins to grow dark with the ascending flowers; a little water will rise
‘ and come into the receiver. Cautiously keep up the fire, that the heat
‘ may not melt the flowers in the head, and yet be sufficient to sublime
‘ the sulphur. Continue thus for eight hours, and at length increase the
‘ fire, till the lower rim of the head grows almost so hot as to melt the
‘ sulphur: the sulphur will now be sublimed into a yellow, light, rarified,
‘ soft, powdery substance, called flowers of sulphur.

‘ 2. This experiment is sufficient for our present purpose; but those who
‘ make flower of brimstone for sale, have entire furnaces built for the pur-
‘ pose, with two chambers or partitions, one containing the sulphur to be
‘ sublimed, where the fire is placed, and the other adjoining to it, commu-
‘ nicating therewith, and kept cold. Both of them are exactly stopped up
‘ to exclude the air; and thus the sulphur being urged in one chamber, by
‘ the heat of the furnace, and rendered volatile, flies into the other which
‘ is cold, and there collects together. When the operation is ended, and
‘ all grown cold, the furnaces are opened, and the flowers swept out; and
‘ thus they repeat the operation with fresh sulphur. And as they thus pre-
‘ pare the flower of sulphur in large quantities, with little labour and small
‘ expence, hence it is usually sold but little dearer than rough brimstone.

The use.

The sulphur, by this means, is attenuated and purified; in other respects
it is not changed; but thus it becomes very fit for internal medicinal use.
For when thus divided, it exerts its virtues to greater advantage in the body;
and thus also it proves fitter for external chirurgical uses, chiefly when it
comes to be mixed with balsams, liniments, and unguents. And hence we
understand its wonderful nature; for tho’ ever so often sublimed, it always
remains the same, without being changed or mixed: it therefore can never
become a metal, or enter the composition of metals. This, therefore, is
not the sulphur of the philosophers, nor can ever be made to afford it; as
being no more than an oil mixed with an acid. So long as the air is
excluded from this sulphur, heated even to the degree of fusion, it re-
mains unchanged by the fire; but as soon as the free air is admitted, it
presently takes flame, and then soon changes, and divides into separate parts.
Paracelsus directs these flowers to be sublimed from the red calx of vitriol,
and recommends them for the cure of exulcerated lungs. I made the ex-
periment, but without finding that these flowers, which he so much com-
mends, had greater virtues than the common flower of brimstone.

PROCESS CII.

The acid spirit of sulphur.

1. **C**HUSE a cool, moist, still day, and melt pure flower of brimstone, in an earthen cylindrical pan, three inches deep, and as many over. When the sulphur is thoroughly melted, but not fired, put the vessel under a chimney that does not smoke, but discharges all fumes made upon the hearth. Now light up the melted brimstone, and immediately cover it with a glass-bell, the centre whereof is over the centre of the flame. The bell should first be suspended in the vapour of hot water to moisten its internal surface, and let it be so supported by bricks, set triangularly, as not entirely to extinguish the flame of the burning brimstone; otherwise the nearer it is to the flame, the better. As soon as the flame begins to go out, let there be at hand another similar vessel full of melted brimstone, to be fired and applied as the former; and continue thus for a whole day. A strong-smelling acid vapour will begin to collect in the bell; especially during the coldness of the night; apply a little glass-receiver to the bell, which is to be set so inclining, as that the liquor may gently run out of it into the receiver. Thus by continuing the operation, and increasing the number of the bells, there will be obtained a gratefully acid, ponderous, yellow, and sometimes red liquor, that is wonderfully fixed at the fire, so as to require almost the same heat to raise it as oil of vitriol. It also strongly attracts water; and therefore gradually increases its weight in an open glass. If all these directions be well observed, the operation will always succeed. The vapour here must be carefully avoided.

2. Mr. *Homborg* finding this method too tedious, has invented a much easier and better, whereby five ounces may be obtained in twenty-four hours (a). He took the most capacious glass-receiver he could get, and cut a round hole in the bottom thereof, eight or ten inches wide. This is done by first finding the centre of the basis, by letting a plumb-line fall down thro' the mouth of the glass till it touch the bottom, and remain every way equidistant from the sides; the point of contact is marked with a diamond; then setting the foot of a pair of compasses on that point, and opening them to the distance of five inches, the periphery of a circle is struck with ink. When the line is dry, it is to be cut with a diamond, the deeper the better. Then have at hand an iron ring, of the exact size with the circle drawn. When the iron is heated, apply it to the round line, and the piece will fly off, and leave the basis open. When the bell is thus procured, paste a slip of strong linen about the neck, with a loop-hole for a string to run thro', in order to suspend the bell: then have ready a cylindrical earthen pan, six inches wide, full of pure melted sulphur; light it, and set this vessel upon a glazed earthen foot, placed upon

(a) See *Memoir. de l'Acad. An.* 1703. pag. 31, &c.

the rising part in the middle of a large glazed dish; suspend the bell exactly over the middle of the flame, at such a distance as not to extinguish it. Make the sulphur always burn equably, by supplying it with new, and taking off the crust with an iron rod, when it grows hard; so that the distillation may thus proceed uninterrupted. The other particulars above-mentioned, of moistening the inside of the bell with a warm aqueous vapour, of taking the opportunity of a cold, moist, still air, and of a chimney that does not smoke, are here also to be regarded.

The use.

The sulphur sublimed into flowers, is freed from its earth and metallic part. When lighted, after being melted, it burns only on its surface contiguous to the air; its blue flame consists of fire, or the inflammable oily part of the sulphur, agitated by the fire, and a mineral acid, which is the other constituent part of the sulphur, now agitated, attenuated, made caustic and volatile, by the flame. Thus the unctuous combustible matter is consumed by the fire, and the ponderous acid dissipated, which soon after condenses by its own weight, when it gets clear of the flame that throws it off. And hence this vapour becomes so mortal, because the violently caustic acid, thus strongly agitated, comes in contact with the nerves, which move the muscles, that join the interstices of the cartilaginous rings of the *larynx*, *bronchia*, and *vesiculae* of the lungs; whence it contracts them spasmodically, so as to stimulate the lungs into a panting endeavour to cough, whilst they are entirely contracted, and not suffered to expand by the weight of the air; altho' the breast be dilated with a laborious but fruitless endeavour. The same vapour, shut up with fermentable liquors, stops fermentation; and if strongly repeated, prevents putrefaction in all bodies that otherwise easily putrefy. Hence this fume is a proper preservative against pestilential poison, and the contagion that flies abroad, or remains fixed in goods, so as to infect them. And hence we understand why the flame of nitre and sulphur together, but chiefly of gunpowder, afford a very healthy fume in the height of the plague; for the explosive acid vapour of nitre and sulphur corrects the air; and the same vapour, if received in a small close pent up place, kills insects. This spirit of sulphur, called by the name of *oleum sulphuris per campanum*, is no other than the oil of vitriol, which was lodged in the vitriolic pyrites: and afterwards, joining with the oil of coals, constitutes sulphur. This appears from all kinds of trials; only oil of vitriol is suspected to contain some metallic impression, which is wanting in the spirit of sulphur, prepared from the flower of sulphur. The great *Homborg* has, with much labour and subtlety, computed the quantity of this acid contained in sulphur, and found it to be nearly a tenth part. And thence, perhaps, we have the reason why alcohol will not touch sulphur, *viz.* because its oil is saturated with acid: and again, why a tenth part of alkali, mixed with it by the fire, occasions alcohol to dissolve it, *viz.* because thus having alkali to absorb the fixed acid, it leaves the oil free to dissolve in the alcohol: and again, why sulphur resists acids, and is not resolved thereby: why when once dissolved with its own acid, it admits no more: why metals melted, or calcined with

fulphur, are corroded thereby, viz. because the acid of the sulphur, forsaking its own oil, is strongly attracted into the metals, and thus corrodes them into a kind of vitriol. And hence let those less skilful chemists grow more prudent, who endeavour to fix sulphur; which is only a fossil acid united with an inflammable oil; and no longer attempt to fix metallic mercury therewith; for such heterogeneous things cannot enter each other: nor can they give the gravity and solidity here so requisite, nor indeed the simplicity or malleability. This spirit of sulphur, being purified, barely by standing, then mixed with juleps, gives them an agreeable acidity, and renders them a wholesom drink in all inflammations, and hot diseases, attended with thirst and corruption. *Helmont* says, it is conducive to the prolongation of life.

PROCESS CLII

Sulphur dissolved in fixed alkali.

TAKE nine drachms of pure flower of sulphur, melt it in a crucible, and add two drachms of dry fixed alkali in powder; the sulphur will presently begin to change of a new and particular odour, and of a high red colour; stir the mixture over the fire with a tobacco-pipe, then, when thoroughly melted and united, pour it out upon a cold marble. It will be a red, brittle mass, soluble in water, and soon relenting in the air; whereas the sulphur before would neither resolve by the action of the air, or water.

The use.

The fixed alkali, being here actuated by the fire, intimately unites with the melted sulphur, attracts its acid, and joins therewith, so that the sulphur resolves into its two separate principles; yet the oil does not here remain separate, but is intimately united with the alkali, and acid salt, so as immediately to produce a wonderful soap, consisting of acid, alkali, and oil; and therefore the combination of the fossil acid, alkali, and oil, in the composition of sulphur, changes the oil to another nature; but the acid remaining almost unchanged, comes out the same upon the resolution; and hence we may understand the power of fixed alkali in metallurgy. Sulphur is often mixed with metals, and makes them brittle; but, if fixed alkali be added to them in fusion, it takes the sulphur into itself, from the metal, and floating upon the surface, as a lighter soap, leaves the heavier metal, now freed from its sulphur, to fall to the bottom, in the form of a regulus, whilst the alkali has no entrance into, or power upon the metal. Hence, therefore, if there be any doubt, whether any fossil glebe or ore contains sulphur, the way is to grind and melt it with fixed alkali; for thus the alkali will manifest the sulphur by the colour and smell produced.

PROCESS

PROCESS CLIII.

Sulphur dissolved in volatile alcali.

MIX any strong alkaline spirit, whether prepared from sal-ammoniac, hartshorn, blood, or the like, with pure flowers of sulphur; distil, and cohobate, by which means the sulphur will be dissolved: or if the mixture be long kept in a close vessel, and frequently shook, by this means, also, a golden tincture may be obtained.

The use.

This process serves to shew the power which volatile alcali has upon the acid of sulphur, and the consequent change thereof. But whether the tincture possesses such great medicinal virtues, especially in diseases of the breast, as an eminent chemist imagined, may be justly questioned.

PROCESS CLIV.

The solution of sulphur in alcohol.

TAKE sulphur, first opened by fixed alcali, as in the hundred fifty-second process, and whilst it remains still hot from the fire, and consequently dry, grind it fine in a hot and dry mortar; put it into a dry glass, and pour pure alcohol thereon, so as to float five inches above it. The alcohol thus perfectly dissolves the sulphur, as soon as it comes in contact therewith, into a rich, gold-coloured, unctuous liquor, which, by shaking, becomes still richer. Let the tincture be decanted clear from its faeces, pour fresh alcohol upon the remainder, and this being again tinged, separate it, and repeat the operation, till the alcohol becomes tinged no longer. Keep all the tinctures mixed together: they make a liquor that has a very particular smell, tho' not ungrateful, but with some fragrance. It is of an-exceeding aromack heating taste, and of a corresponding medicinal virtue: the faeces left behind are grey-coloured, saline, and earthy.

The use.

Alcohol will not touch native sulphur, tho' ever so long digested therewith, but as soon as the sulphur is opened by alcali, it is then eagerly taken up by alcohol; so that I scarce know any quicker solution. Hence we learn the power that alcalies have upon sulphur, for procuring entrance to alcohol. Sure, therefore, sulphur frequently lyes concealed in many fossil glebes, but especially in ores; whence it happens, that a simple tincture of sulphur has often been sold for the most secret and valuable metallic tinctures, even to princes: and I remember a boasted tincture of gold thus put off for *aurum potable* at a high price. This tincture was made by mixing gold with crude antimony, and the alcali of tartar, or Glauber's alcahest, melted

melted and stirred together; then the whole being afterwards bruised, and brought to powder, it afforded a golden tincture with alcohol: but this, I say, was a mere tincture of sulphur; for the gold here remains unchanged: but antimony abounds with sulphur, and in melting, the alcali attracts this sulphur, separates it from the metalline mass, and opens it; then the alcohol, being added to the whole ground mass, extracts only the sulphureous part opened by the alcali, and leaves the gold, or metallic part of the antimony, perfectly untouched. And this observation is of infinite use in examining numerous other sham-tinctures; for as soon as a skilful artist knows that fixed alcali is employed in making them, he knows they must proceed from sulphur; because the metallic, or as chemists call it, the mercurial part, is never touched by vegetable alcali. In the mean time our tincture of sulphur affords a wonderful warming medicine, that causes eructation, resists acids, and cuts phlegm; a few drops of it being taken upon an empty stomach, in mead, *Spanish* wine, or any proper syrup, which it thus turns white, so as to be called the milk of sulphur. But I could never discover its antiphthifical virtue, as a last refuge in ulcerated lungs, tho' I have diligently sought for it; notwithstanding the great Dr. *Willis* has wonderfully recommended it in this distemper; but I judge such preparations should be more sparingly praised by physicians.

P R O C E S S C L V.

The syrup of sulphur.

TAKE a drachm of sulphur, opened with alcali; dilute it with thrice its weight of water, wherein it almost wholly dissolves; add to the solution twice or thrice its weight of sugar, a little boiled; mix them together, and thus a kind of syrup of sulphur is prepared, containing the virtue of the open'd sulphur, and may thus be conveniently employed for medicinal uses. It is made more expeditiously by mixing the tincture with six times its weight of the syrup of liquorish, or other the like syrup.

The use.

What opinion physicians should have of this composition we hinted above, in considering the tincture of sulphur. The syrup is heating, drying, and stimulating, which are properties that do not suit coughs and consumptions; especially where the body is wore down, and attended with constant sweats. But hence we advantageously learn, how wonderfully the powers of fossils may be concealed in almost every thing; for if any fossil glebe, rich in metals and sulphur, be first gently washed, ground to powder, calcined with fixed alcali, and afterwards dissolved in water, syrup, wine, alcohol, or other liquors; the alkaline sulphureous part easily dissolves, and lyes concealed. Whence the liquor receives some particular virtue which should be carefully examined, before the liquor is used internally.

P R O C E S S

PROCESS CLVI.

Sulphur dissolved in vegetable expressed oil.

TO a quantity of any express'd vegetable oil, contained in a glazed vessel, set over the fire, add a fourth part of the flowers of sulphur as soon as the oil is sufficiently hot as to dissolve the sulphur, which will now fall to the bottom of the oil, like a highly red shining liquor, and they will remain with this degree of heat, for a long time, unmixed; but the fire being gradually increased, tho' with care to prevent the matter from taking flame, at length, when the oil begins to fume, it will intimately mix with the sulphur, and the whole become opaque, and form a new and entire body of the two. If more sulphur be added, this also may be easily dissolved by bringing the oil to fume, and almost to boil; and thus at length a considerable quantity of sulphur may be dissolved in a small proportion of oil, so as perfectly to lose its former nature of sulphur.'

The use.

This is the famous balsam of sulphur of *Helmont*, *Rulandus*, and *Boyle*, concerning which let the noble authors themselves be consulted, who very highly commend it for heating, mollifying, and resolving, when used externally; and internally against putrefactions, and suppurations of the kidneys and lungs especially, declaring they have thus found a secret but sufficient remedy for consumptions of the lungs: but, I judge, that by its acrimonious, indigestible, and hot unctuous part, it offends the weak lungs, the stomach and viscera of languid persons, spoils the appetite, increases thirst, and parches the body, already too much dried by the distemper. And this I speak not rashly, but upon experience and consideration; and therefore advise it to be sparingly and cautiously used, with a careful observance of the effect: certainly, it is not without a burning rancidness, as being found, when externally used, successfully to cure pale, cold, watery, mucous, sanious running ulcers: perhaps, it was hence somewhat too hastily concluded to have the same effects when used internally; for thus it raises and continues a fever. The chemical use of the experiment shews, that sulphur, which remained untouched in alcohol, the most subtile of oils, does expeditiously, and almost totally dissolve in a very thick and sluggish oil, strongly heated by the fire; which evidently shews, with regard to the history of menstruums, that an extreme degree of subtilty and penetrability does not here perform what may speedily be effected by a sluggish and viscous matter. But this is not all; chemists often wonder that many fossils, which remain untouched by the sharpest acid liquors, should yet be successfully resolved by a mild and indolent oil. Sulphur does not yield to any acid menstruum; for there is no known acid stronger than that already contained in the sulphur, whence others cannot act upon it; but sulphur is dissolved by oil: as often, therefore, as a fossil glebe, when boiled in oil, affords such a sulphureous balsam, the oil must act upon the sulphureous part of the matter, unless

unless we except lead; which is a metal that dissolves into a balsam with oil, as we shall see in the hundred seventy-seventh process.

PROCESS CLVII.

Sulphur dissolved in a distilled vegetable oil.

PUT an ounce of the flowers of sulphur into a tall bolt-head, pour thereon six times the weight of the ætherial oil of turpentine; let them boil in our little wooden furnace, for an hour; the sulphur will first melt at the bottom, and part of it be dissolved in the oil that floats above it, with a crackling noise, till at length the whole sulphur will appear dissolved in the oil. Let all cool, and a large proportion of the sulphur will appear concreted into yellow spiculæ at the bottom; the balsam remaining at the top, so that the sulphur seems precipitated by a true crystallization in this balsam. Pour off the clear liquor entirely from the golden sulphureous crystals, into a clean vessel apart; add fresh oil of turpentine to the remainder, boil as before, and all the sulphur will be dissolved into a balsam; but when suffered to cool, it again shoots into sulphureous crystals. Again, pour on more oil, and continue thus, till all the sulphur is perfectly dissolved; whereby it will appear, that one part of sulphur requires about sixteen of this oil to dissolve it entirely. Keep all the balsams, thus prepared, under the title of balsam of sulphur from turpentine. This operation requires the utmost care, as being attended with danger; for if the mouth of the vessel was stopped, the boiling matter would burst the glass with greater violence than has been hitherto observed in any other experiment; of which terrible accident Doctor Hoffman gives an instance (a).

The use.

Hence we see, that a thin, penetrating, sharp distilled oil cannot well dissolve sulphur, tho' a mild, gross, and indolent oil so easily does it, as we saw in the preceding process; whence it should seem that the more subtle the oils are, the more unfit to dissolve sulphur, as appears remarkably in alcohol. It appears also that sulphur dissolves in distilled oils, as salt dissolves in water, till the water is saturated; but afterwards is thrown off into crystals. The explosive force of this balsam of sulphur is the most violent of any that is known. This balsam consists of the oil of sulphur, the oil of turpentine, the perfect acid of sulphur, made by the bell, and a fixed earth (b). This balsam is an extemporaneous anodyne remedy in pains of the nerves, and an excellent medicine in sanious, sinuous, weeping, watery, and fistulous ulcers. Internally taken, it is heating, diuretic, and sudorific. It is recommended for cleansing and healing internal ulcers; it is hence too highly commended for the phthisic, ulcers of the kidneys, and for expelling and dissolving the stone: but the cautious physician will recommend only the

(a) See *Observ. Phys. Chem.*(b) See *Memoir, de l'Acad. Roy. An. 1709. pag. 46.*

gentle medicines, and be afraid of those that operate violently: It is certain that the urine is soon impregnated with a violet smell, upon taking a little of this balsam; and hence also the tinctures of fossils, extracted by art, with distilled oils, are falsely received for the tinctures of metals. This is called the terebinthinated balsam of sulphur; and as other distilled oils may be thus mixed with sulphur, the balsams, so prepared, receives their names from the distilled oil employed, that gives them their prevailing odour. Hence the *balsamum sulphuris amifatum, succinatum, juniperinum, &c.*

PROCESS CLVIII.

The soap of balsam of sulphur.

1. TAKE the balsam of sulphur, as prepared in the hundred fifty-sixth process; dilute it with twice or thrice its weight of the same oil as was used in its preparation, and herewith make a soap, in the manner explained under the seventy-third process. This will be the soap required, which *Starkey* in his *Pyrotechny* so highly commends from *Helmont*.
2. Or take the balsam of sulphur, of the hundred seventy-seventh process, and therewith, instead of simple oil of turpentine, make a soap in the same manner as under the seventy-fifth process: this soap will be the sulphureous soap of the philosophers.

The use.

These processes shew the ways whereby natural simple sulphurs, as also such as closely adhere to semi-metals, as the sulphur of antimony, &c. may be joined to fixed alkaline salts, and thus become miscible with nearly all the animal juices, and exert their virtue in all the vessels of the body. The followers of *Helmont* hence promised themselves wonderful medicinal effects, not easily to be obtained by other means; because in these sulphurs, so opened, they find a great solutive power, which is manifest by their disagreeable odour, their ungrateful, and highly penetrating and heating taste; but the same effects may be had in the soap described in the seventy-third and seventy-fourth processes, without the disagreeable odour, and rancidness. These processes however have their chemical use.

PROCESS CLIX.

The balsam, or soap of sulphur, united with alcohol.

1. TO the terebinthinated balsam of the hundred fifty-seventh process, contained in a tall bolt-head, add six times its weight of pure alcohol, and make a solution; which having stood for some time, the sulphur in part precipitates out of the balsam, into sulphureous crystals, and in part remains dissolved, so as to afford an alcoholized balsam of sulphur.

The Practice of CHEMISTRY.

* 2. Or take the terebinthinated soap of sulphur, as described §. 2. in the preceding process; digest it with alkali; and this makes perfectly the same solution, of a very penetrating taste and odour.

The use.

And here is the limit of the processes upon sulphur; but we must observe, that when sulphur is dissolved with alcalies, and precipitated with acids, the mixture grows white, and affords the ungrateful odour of putrefied excrements, when surprising phenomena ensue; which also hold in other fossils so treated: whence the cause may be understood. For example, if vinegar be added to the golden tincture of sulphur, made according to the hundred fifty-fourth process, there soon rises a stercoraceous odour from the precipitated sulphur; and if the tincture of antimony, prepared by melting the antimony with alkali, and then extracting it with alcohol, be mixed with vinegar, the same thing happens: and this may help us to understand what is observed in the processes upon the semi-metallic sulphureous fossils.

PROCESS CLX.

Sulphur produced from oil and acid.

* TAKE four ounces of pure rectified oil of turpentine, put it into a retort, and let fall thereon, by a drop at a time; an ounce of highly rectified oil of vitriol; shake the retort, after the addition of each drop, that it may be thoroughly mixed. The liquor will now heat, smoke, grow red, and exhale a variable odour. After the whole is thoroughly mixed, digest it for eight days; then apply a capacious receiver, and distil in a sand-furnace, the juncture being well luted; a new and particular oily liquor will come over. The matter at the bottom appears first like a fluid *bitumen*, but gradually thickens, and at length becomes pitchy, and betuminous; the liquor that comes over is fetid, sulphureous, and suffocating, if received into the lungs. If the distillation be carefully carried thro' with successive degrees of fire, there will at length arise a true sulphur into the neck of the retort, as may appear from its form and manner of burning.

The use.

Hence we learn the artificial method of preparing bitumen and sulphur; and that the fixed acid of vitriol, alum, and burnt sulphur, is the incombustible basis of sulphur, whilst the other part is the combustible pure oil; which two, by their intimate union, compose sulphur. If this factitious sulphur be burnt, its oily part affords a flame without smoke; and the other part, in the burning, affords an acid, caustic, suffocating vapour, which is preservative and ponderous, so as not to rise high, and if condensed by a glass-bell, it drops down into oil of vitriol, exactly like that of the natural sulphur. A pure inflammable oil seems to be collected in sulphur, such as can scarce

be otherwise obtained; whilst the gross, unflammable, terrestrions, or other saline matter is excluded in this combination: no other acid, produced by nature or art, will make sulphur by mixing with oil. The acid of vitriol, wherever it be, or wherever subtly concealed, joins with any inflammable oil, so as to make sulphur. Tartar of vitriol, *Glauber's sal mirabile* of sea-salt, and of nitre, the salt of vitriol, burnt alum, and other bodies, containing this acid, as often as they are, by means thereof, joined with an inflammable oil, always afford true sulphur. Hence, this acid alone has the property of producing sulphur, whilst all inflammable oils serve therewith for the same purpose; and hence sulphur can never be produced where this acid did not pre-exist: whence numerous obscure particulars may be understood in the chemical history of fossils and metals; and therefore, whoever would explain them, should remember what is here delivered. To give an example from *Becher*: melt *Glauber's sal mirabile* in the fire, throw powdered wood-coals thereon, a sulphureous flame arises, and a brown mass is left at the bottom, which being dissolved in water, and precipitated, a true sulphureous matter is obtained. Here it is plain, that the oil of vitriol in the *sal mirabile* lays hold of the inflammable matter in the coal, and becomes sulphur: therefore, in determining the effect of any chemical operation beforehand, we must cautiously examine whether any of the matters employed, either manifestly, or secretly contain the oil of vitriol, alum, or sulphur, and whether any inflammable matter is also applied; for in this case the action of sulphur is immediately produced.

PROCESS CLXI.

Sulphur obtained from alcohol and acid.

‘ INTO a tall glass-body put eight ounces of alcohol, prepared without
‘ alkali; let fall to it, by a drop at a time, highly rectified oil of
‘ vitriol; shake the glass well after each drop, and rest a little, otherwise
‘ a great heat, and suffocating vapour would arise; continue thus, by de-
‘ grees, till an ounce of the oil of vitriol is added. The mixture will
‘ have the sweet fragrance of southern-wood, which will spread over the
‘ whole place; but it ought to be avoided, as being suffocating; if receiv-
‘ ed in a small quantity into the lungs, it causes a violent cough; and if
‘ received in a large quantity, at once, I judge, it might prove mortal:
‘ the liquor will become reddish. Let it now be gently digested, in a close
‘ vessel for five days, then distil it gently in glasses close luted; a wonder-
‘ ful subtle spirit will come over, which proves incredibly suffocating, and
‘ is so much the more dangerous as, by its grateful smell, it treacherously
‘ leads one to take it in freely. Continue this gentle distillation for some
‘ time, till the mixed matter grows black; then the spirit, which last came
‘ over, will be exceeding sweet and fragrant. And now there will begin
‘ something acid to rise, which was not in the former liquor; then change
‘ the receiver, still keeping a gentle but constant fire, that the liquor may
‘ rise slowly; for if the fire was to be urged too strongly, but for a moment,

the matter would immediately swell and rarify, so as to come over at once into the vessels, and disturb the operation. If the distillation be thus gently continued, there arises an aqueous, fetid liquor, and along with it another that is ponderous, pure, limpid, and keeping separate and unmixed with the phlegm. After all this is come over, and about one half of the whole, again change the receiver, and distil by degrees of fire up to the highest; a fetid liquor will arise that does not mix with the former ponderous kind: at the bottom of the vessel remains a black, brittle, and uninflamable matter, tho' otherwise, in some degree, approaching to sulphur; so that by this means we have three distinct liquors arising from this mixture, as also a suffocating vapour, and a fixed *caput mortuum*, of a very particular nature, remaining behind.

The use.

The strongest fossil acid, by thus barely mixing with the most subtile vegetable oil, or alcohol, causes such a violent heat, as, if imprudently mixed, almost to take flame, and produce a considerable effervescence. At the instant of mixing there arises a sweet odour, which diffuses itself widely; but by a long digestion, the disagreeable odour of garlick is produced. The sweet suffocating odour is attended with an acid. Here, (1.) a spirituous, fragrant, suffocating, inflammable, and tartish liquor is separated; whereas the oil of vitriol was a little before so fixed, and no way fragrant. (2.) There comes over a fetid, sulphureous, aqueous, uninflamable acid liquor, tho' neither the alcohol, nor oil of vitriol contain much water. (3.) There comes over a limpid ponderous liquor, that smells and tastes gratefully aromatic, but will not mix with the two former, yet dissolves in alcohol, and then extracts somewhat of a tincture from calcined gold, and hence is esteemed the philosophical oil of vitriol. It is certainly a dulcified oil of vitriol, concerning which *Isaac Hollandus*, *Gesner* (a), *Mr. Boyle* (b), but particularly *Doctor Hoffman* (c) may be consulted. The black faeces being diluted with water, return almost into acid oil of vitriol. We have here a great many unexpected phaenomena from a simple combination; perhaps this may be the philosophical spirit of wine, which, by its fragrance, calls in the neighbours while it is made, according to *Lilly's* account of it. Perhaps it is the dulcified fragrant spirit of vitriol of *Paracelsus*, which he esteemed powerful in the falling sickness; and possibly the tincture prepared with it from gold is a species of *Paracelsus's aurum potable*, digested in the stomach of the ostrich. Certainly, this operation may excite the truly curious to examine with care, whether there be any thing of these great secrets concealed therein. We find it does not produce true sulphur, but only certain properties thereof.

(a) *Conrad. Gesner. Euxonym.*(b) *Abridg. Boyle, Vol. III. p. 391.*(c) *Dissert. Phys. Chym. p. 173—180.*

III.

PROCESSES upon METALS.

PROCESS CLXII.

The vitriol of iron.

1. **D**ROP pure oil of vitriol into eight times its quantity of fair water, contained in an urinal glass, and shake them well together, so as to make one pure liquor; throw in a small proportion of clean and bright filings of iron; a great ebullition will arise, and the liquor become opake, hot, and of a dusky colour; and a perfectly fossil vapour, of a particular odour, will arise, somewhat resembling that of garlick. When the effervescence is over, and the former iron dissolved, throw in more, and continue thus till a part of the filings remain undissolved at the bottom; then let the liquor rest to purify, and deposite its fæces: what floats above then will be green, and of a sweetish styptic taste.
2. Let this liquor be filtered, and in a clean glass evaporated to a peltule; set the vessel in a cold, low, still place, and there will soon shoot to the bottom bright transparent green crystals like emeralds. Let the liquor be poured off from them, dry them gently in a warm air, upon paper, and keep them in a glass, where they will long preserve their form. The remaining liquor, being inspissated as before, produces new crystals; and thus at length almost the whole liquor is converted into vitriol; tho' the first crystals are always the best.

The use.

Iron attracts to itself the fossil acid of oil of vitriol diluted in water, exactly as alcali did in the preparation of *tartarum vitriolatum*, according to the hundred forty-eighth process; in which respect, therefore, iron and alcali agree. The iron, thus united with the acid, also becomes soluble in water; and hence the compound acquires the nature of a metallic salt. It consists of water, metal, and acid, united together in a certain proportion: and so long as this proportion remains, so long the mass continues shining and transparent; but as soon as only the water is separated from it by any considerable heat, the whole mass presently becomes opake, loses its pleasant greenness, and acquires a grey colour; in this respect also resembling the crystals of salts; whence the chemists have called it the salt of iron, as also because it flows in the fire: others rather call it the magistery of iron, because the whole body of the iron is concreted with its solvent into an uniform solid mass. It is also called vitriol of iron, because it perfectly, in every respect, resembles native fossil vitriol. And hence we understand the method,

method, whereby the solid bodies of metals, upon uniting with acids, may become, like salts, dissolvable in water, and potable, and thus acquire a new metallic saline taste, and also particular medicinal virtues. If the salt of iron be diluted with a hundred times its quantity of water, and drank in the dose of twelve ounces, upon an empty stomach, walking gently after it, it opens and relaxes the body, purges, proves diuretic, kills and expels worms, tinges the excrements black, or forms them to a matter like clay, strengthens the fibres, and thus cures many different distempers. The like taste, odour, and colour, and the like blackness of the excrements, have occasioned many to imagine that the chalybeate waters were thus produced by nature; especially, because those liquors, when exposed to the air, deposite a copious yellow sediment or oaker: but Dr. *Hoffman* has prudently corrected this error, by means of experiments, in his noble work of mineral waters. However, we must observe that this salt of iron, meeting with alcallescent and putrid matters; and thus having its acid solvent drank up thereby, is turned into an astringent, ponderous, sluggish, metallic calx, that occasions inveterate obstructions, and therefore proves hurtful in putrid fevers. And we know that when iron-filings are taken in female disorders, where the body is weak, languid, and abounds with acidity, the metal thus produces eructations, as of garlick and putrid eggs, on account of the acid it meets with; and hence, the heat before wanting in the body is excited, and the excrements generally turn black; and in this case the powder of iron-filings proves much more serviceable, than when ever so laboriously prepared by chemistry. Whence iron is known to prove useful if acids abound in the body, but hurtful where the body is bilious or hot. This experiment, duly considered, shews us the origin of green metalline vitriol every where in the earth; and that it proceeds from iron, corroded by a fossil vitriolic acid. Lastly, the production of inks principally depends upon this experiment.

PROCESS CLXIII.

Ludovicus's vitriol of iron, with tartar.

1. TAKE one part of the vitriol of iron, not acid, but perfectly saturated, four parts of cream of tartar, and twenty parts of rain-water; boil them together in a glass-vessel, often stirring them with a stick, till the mass becomes grey, thick, and almost consistent; but with care to avoid even the least burning. Put the mass into a tall bolt-head, pour common spirit thereon, so as to float four inches above it; boil them together for an hour or two, and a red liquor will be obtained; when cold, decant and filter it. Treat the remainder with fresh spirit as before, and continue to do this so long as the spirit acquires any redness; then put the several parcels together, which thus make *Ludovicus's* medicated tincture of iron.

2. If the tincture, thus prepared, be evaporated to a pellicule, it loses its spirit, and afterwards shoots, along with the salt of iron, into medicated crystals. And if what remains after boiling with the spirit, be strongly

strongly boiled with ten times its quantity of water, and strained thro' flannel, till the liquor becomes clear, and all the matter be dissolved by the frequent addition of fresh water, and this liquor be at length exhaled to a pellicule, and set in a cool, quiet place; we shall thus again have the opening martial tartar of *Ludovicus*.

The use.

Physicians having observed, that the excellent medicinal virtues of iron, somewhat explained in the preceding process, had their effect so long as the iron continued dissolved in a mild acid, but vanished, and were precipitated into an unctuous calx, upon meeting with an alcali, hence prudently joined the salt of iron with a vegetable acid, in expectation that it might thus pass and act upon all the vessels of the body, whilst it more permanently retained a saline nature; and this was the reason of joining the salt of iron with the vegetable oily salt of tartar, to prevent its being easily precipitated in the body into a croma, or astringent calx. The preparation has the virtue of opening, attenuating, strengthening, and gently evacuating by the belly and kidneys; and hence proves curative in leucophlegmatic, scorbutic, icteric, hypochondriacal, and hysterical cases, or when the body is relaxed, weak thro' the sluggishness of the parts, rickety, or abounding with worms.

It is taken in a morning fasting, in the quantity of a drachm, diluted with six times its weight of water, repeating it thrice, and each time drinking after it a quarter of a pint of thin whey, walking gently upon it, so as not to sweat; this may be continued for nine days, with great advantage. A few drops of it may be given to children troubled with the rickets or worms, (and thence become of a bad habit) mixed with syrup or honey. A drachm. of the calybeated tartar, taken in the morning, answers the same purposes. And hence we see the method of converting metals into medicines, and forms fit for taking; but they are afterwards prudently to be employed: these are found to have very good effects, if they prove gently purgative, and bring away the fæces of a black or grey colour.

PROCESS CLXIV.

The white, grey, and red calx of the vitriol of iron.

1. TAKE half an ounce of dry and good vitriol of iron, reduced to powder in a glass mortar, apply it in a glazed dish to a heat of a hundred and fifty degrees, keeping it continually stirring with a stick; a little watery vapour will fly off, and leave a light white powder, like meal, of an inky, sweet, styptic taste: this is the white calx of the vitriol of iron. 2. If this calx be urged with a stronger fire, of near three hundred degrees, it will become of a greyer colour, and of a more austere taste. 3. If this second calx be calcined in a crucible, in an open fire, it grows yellow, red, and at length becomes a deep purple powder, of an austere taste, and somewhat caustic; which two properties are the

more

The Practice of CHEMISTRY.

' more increased, the stronger the fire, and the longer the calcination ; so
' that at length the powder will become almost caustic.'

The use.

Hence we see that vitriols, or metallic salts, presently lose their transparency, upon losing their water, and fall as it were into ashes ; whence this operation is called calcination, and the thing produced a calx. And when urged with a stronger fire, they no longer remain soluble in water, as constantly appears in the third calx. The first is recommended in medicine, because it retains its native virtue, may be easily mixed with sugar, and thus commodiously given to children. It is usually imagined, that the superabundant acid may be driven away by this calcination ; but oil of vitriol does not rise with so small a heat. The second calx has the like virtues, but is somewhat more astringent, and less soluble in water : but the third is not soluble in the body, yet endowed with a caustic virtue, so that it can seldom be given internally with safety. Externally applied, it is excellent for eating down, and afterwards consolidating the lips of ulcers ; it stops fluxes of the lymphæ, blood and serum : but if this red calx of vitriol be long detained in a violent fire, and afterwards boiled in water, it impregnates the water with a vitriolic sharpness. If the operation be continued till the last water comes off tasteless, an insipid, red, astringent powder, called *crocus martis astringens*, will remain behind ; and is the body of the iron calcined by acid and the fire ; and therefore commonly used for astringing. The acid waters being evaporated to a pellicule, then set to shoot, afford somewhat of a vitriolic salt.

PROCESS CLXV.

The liquor of iron per deliquium.

' IF the red calx of the preceding process be not washed with water,
' but strongly calcined, ground fine, put into an open glass, and exposed
' to the moist air, it relents, and at length dissolves into a kind of liquid
' red matter, that may be called the oil of iron *per deliquium*.'

The use.

The vitriol of iron contains a very acid fossil and water, so that the water being separated by fire, the strong and pure acid remains dry, along with the metallic part alone ; but the acid, being attractive of moisture, relents by the water of the air ; and this is the true reason of the effect : the like obtains in all similar cases. The metals thus dissolved, in their respective acids, then dried, moistened in the air, dried again, are thus by repeated operations at length wonderfully opened, resolved, and even made volatile. The calx of the metals, thus dissolved by the moisture of the air, has the same virtue as the calx above explained.

PROCESS

PROCESS CLXVI.

The golden tincture of the vitriol of iron.

TO a quantity of the red vitriol of iron, prepared according to the third operation of the hundred sixty-fourth process, made perfectly dry, and put into a tall bolt-head, pour twenty times its weight of dulcified spirit of sea-salt; digest for a month, and thus a gold-coloured, sweetish, styptic, inky liquor will be obtained. If this be decanted, and new spirit put on, and the operation be thus several times repeated, the metallic powder will at length remain exhausted, and all the tincture be thus extracted.

The use.

This experiment shews that considerable tinctures may be extracted from metals, without dissolving their bodies; for this is a true tincture of iron, since one drop thereof has an incredible power of producing a black colour, as we shall see in the appendix to our course of processes. But this spirit can never dissolve all the calx, only extract its more soluble part. A few drops of this liquor, being taken in *Spanish* wine, upon an empty stomach, are restorative, kill worms, and raise the vital powers. The chemical *Magi* placed their medicated gold in iron; possibly, therefore, this may be their medicated *aurum potabile* (a).

PROCESS CLXVII.

Iron dissolved in Rhenish wine.

PUT two ounces of bright iron-filings into a bolt-head, and add there to twenty ounces of generous *Rhenish* wine; digest them together in our little wooden furnace, for three or four days, often shaking the glass: let them afterwards stand to settle for twenty-four hours, strain off the wine, which will appear black, and keep it in a close stopped vessel; it is of a sweetish inky taste: pour fresh wine on the remainder, and proceed as before; thus also a calybeate wine will be obtained, but no way comparable to the former; for the particular part hence obtainable is soon extracted from the iron by the wine; the whole body of the metal not being here dissolved: so that the production is not a solution, but a tincture.

The use.

Hence it appears, that iron contains one part which is soluble, and another that is insoluble in this mild, fermented, oily, vegetable acid. The former part is the noblest remedy I am acquainted with, for promoting that power in the body by which the blood is made, as often as it happens to

(a) See *Tacben. Hippoc.* pag. 11. and *Basil. Valent. de hoc tinctura.*

be weakened, thro' a bare debility of the over-relax'd solids, and an indolent, cold, aqueous indisposition of the juices. If an excellent medicinal virtue may, by any experiment, be gained from metals, certainly it is this; for no virtue of any vegetable or animal substance, no diet, nor regimen, can effect that in this case, which is effected by iron: but it proves hurtful where the vital powers are too strong, whether this proceeds from the fluids or solids. I have often thought whether this was not the potable sulphur of the metal, that so powerfully resists the debility of nature; a medicine infinitely superior to the boasted *aurum potable*, and a medicine that never proves pernicious when given where required. Hence we see that iron has a part not very remote from a vegetable, and even an animal nature; and which is extremely easy to dissolve. If a drachm of this chalybeate wine be mixed with thrice its weight of sugar, boiled to a proper consistence, and be prudently given in the proper cases, it makes an incomparable remedy for the young of both sexes.

P R O C E S S C L X V I I I .

Iron dissolved in vinegar.

* **P**UT an ounce of clean iron-filings into a tall bolt-head, and pour thereto twenty ounces of the strongest distilled vinegar; boil them together in our little wooden furnace for twenty hours, and when cold, there will be obtained a highly red, and styptic liquor, nauseously sweetish, and thicker than that made with wine in the preceding process. This being filtered makes the astringent tincture of iron, and stains the glasses wherein it is kept, so as scarce possibly to be got off again. If fresh vinegar be poured upon the remainder, it again extracts some tincture, but less, and of a weaker colour than before, tho' still chalybeate. At last, there is left a considerable quantity of metallic matter, that can be no farther dissolved by vinegar.

The use.

It is surprising there should be so great a difference between the tincture of iron prepared with vinegar, and that with wine, both in regard to colour, taste, odour, consistence, and effects. It is hence plain, that iron may easily, and in very different methods be dissolved by acids. This solution of iron by vinegar is wonderfully astringent, and therefore corroborating, and good against worms; though not to be every where rashly employed: it proves more agreeable, if mixed and taken with sugar. Hence we see how easily iron dissolved may enter the human body, and how often, since iron is daily treated and dissolved by acids, and the solution drank down; and hence, possibly, by insinuating into the humours, it may contribute to generate the stone in the bladder, as Dr. Lister conceived. Thus much is certain, that iron grows almost every where, is daily consumed, rises out of the earth, and returns to it again. If any metal be changeable, or destructible, it is certainly iron.

P R O C E S S

PROCESS CLXIX.

Iron sublimed with sal-ammoniac.

TAKE four ounces of bright iron-filings, and as much dry flowers of sal-ammoniac, grind them together in a glass mortar, the longer the better. Tho' these two bodies were separately inodorous, there now presently rises from them a volatile, subtile, and, as it were, an alkaline vapour, because the acid of the sal-ammoniac is attracted into the iron; whence the volatile alkaline part of that salt, beginning to be set free, spontaneously flies off. Let a capacious and dry glass-body be at hand, with a wide mouth; put the powder into it, that it may lye thin spread at the bottom. Lute on an alembic-head, with a common mixture of meal, apply a receiver, set the body in a sand-furnace, and bury it up to the lower rim of the head: first make a fire of two hundred and twenty degrees, and there will come over a sharp vapour that condenses into a highly penetrating, volatile, alkaline liquor. When no more ascends with this degree of heat, raise the fire, that the alembic-head may grow hot; white exhalations will now rise, and afterwards others of various colours; the whole cavity of the head will be covered with mixed variegated colours, white, red, yellow, green, blackish, so as to represent various flowers, from whence the preparations take their name. Proceed with the same degree of fire for six or eight hours, then let all cool, and there will be found in the receiver a gold-coloured, volatile, alkaline and highly penetrating liquor, along with a little white and yellow matter. In the alembic-head and its pipe will be found a very subtile and dry matter of various colours; this is immediately to be taken out, and put into a dry and hot glass, to be kept carefully stopped; for it would soon dissolve by the moisture of the air, and then run into a gold-coloured, fattish, austere, saline liquor. In the first dry form, it is called the flowers of iron; and in the latter moist one, the oil of iron *per deliquium*. The same matter of the flowers every where sticks to the sides of the body, tho' it is here more compact, and as it were melted, and runs strong together by the greater force of the fire: this also is to be taken out and kept dry. At the bottom of the body there remains a brownish-red matter, of a very austere taste; this matter attracts moisture, and presently resolves in a humid air, and runs into a thick, gold-coloured, astringent liquor, which is another metallic oil *per deliquium*. This matter usually swells greatly upon being exposed to the air, and thus resembles some kind of fermentation; but the flowers and this remainder differ in many respects.

The use.

Sal-ammoniac consisting of the spirit of sea-salt, and the volatile alkali of animals, being here ground with the iron, unites some part of its acid with the metal; at the same time letting go some part of its alkali, which therefore becomes volatile; the other part of the sal-ammoniac retaining its nature,

nature, and remaining mixed with the iron, now corroded by the acid, separates a particular part of the iron, which is otherwise fixed in the fire, and carries it up. But it is not so easy as some write, to sublime all the substance of iron by means of sal-ammoniac; but it here seems to be divided into a more volatile part, that rises, and another more fixed part, that stays behind; at least, it appears thus to me; whence I conceive the iron is thus separable into different parts. Hence also we may understand the particular volatility of sal-ammoniac, which is able to sublime a metal, naturally so fixed, and so hard to melt, as iron; whence the philosophers have called this salt the rapacious bird, the white eagle, and the key that unlocks the bodies of metals. These flowers have the same virtues as Mr. Boyle commends in the *ens veneris*; for they are a wonderfully restorative, warming and opening medicine, containing the open body of the metallic sulphur. They have also an anodyne virtue, and are often somewhat soporiferous. The dry flowers, being digested with alcohol, afford a copious golden tincture, both metallic and sulphureous; and the remaining *caput mortuum*, after the sublimation, affords the same with alcohol. The curious and industrious expose the remaining body of the iron and salt to the air, where it resolves; then they coagulate, and inspissate it, and repeat the operation, till at length they so wonderfully and deeply disbowel the metallic mass, as not to repent their trouble and expence. What chemist is ignorant of that rule, so often inculcated, dissolve and coagulate? but whether by repeating this operation, mercury might be obtained from the resolved body of metals, is another question. I have tried it, tho' without success; but the experiments upon metals, by means of sal-ammoniac, are of infinite use.

PROCESS CLXX.

Extraordinary effects upon applying iron to sulphur.

1. TAKE of iron-filings, and flowers of sulphur, each an ounce, grind them together in a glass mortar, the longer the better; they will thus grow hot, and smell strong; then boil the powder in water for half an hour, pour off the water, strain and reserve it; treat the remainder as before: the several waters, when put together, will taste somewhat inky, and when inspissated, leave a little pure vitriol of iron behind.
2. Take eight ounces of the like mixture of iron and sulphur, make it up into a thick paste with water, squeeze this paste strongly into an earthen pot, and set it by; it will soon spontaneously begin to grow hot, send out fumes, and at length often takes fire. When the heat is over, the matter will be found changed into an uniform mass; which being well ground, and boiled with water, as in the former case, affords a pure vitriol of iron for medicinal use.
3. Melt sulphur over the fire, and plunge the end of an iron rod into it for some time; the part, so plunged, will thus become calcined and brittle. In the same manner, if iron-filings be put into melted brimstone,

a *crocus*

‘ a *crocus* of iron, may be obtained, which, when ground to powder, becomes almost the same thing.

‘ 4. If sulphur be thrown upon red hot iron, it makes the iron presently run into calcined metallic drops, which also, when ground, afford the like calx.’

The use.

In these four experiments the highly acid oil of vitriol, which makes one part of the sulphur, coming by means of trituration, or fusion, to touch the metallic part of the iron, in numerous surfaces, it begins to act thereon, after the same manner as in the hundred sixty-second process; forsaking its oily part, and uniting with the iron. And as this action always generates a violent heat, it is no wonder if at length it fires the other oily part, which is easily inflammable, especially if the quantity were large, sufficiently compact, thoroughly ground, and close compressed (a). And as soon as by any of these ways, the acid of the sulphur has corroded the metal, a pure vitriol of iron is produced; because there is no metallic foulness in the flowers of sulphur: and by this means artificial chalybeate mineral waters may be truly produced. These powders are called *crocusses* by the chemists, on account of their colour, and are of the aperient kind, as having an aperitive, vitriolic virtue; whereas other powders, prepared by the means of acid and fire, are called astringent. And thus I think myself to have shewn, by means of the several processes from the hundred sixty-second to the present, the principal ways whereby iron is so changed, as at length to afford preparations always of very different forms, and sometimes such as the metal would not have afforded by the means of fire, or any thing else, besides what we applied. But particular metals require particular treatments; in which respect a variety of operations is required.

P R O C E S S C L X X I.

The calx of lead by the vapour of vinegar.

• TAKE a large glass-body, cut so as to have a very wide mouth, with
• an alembic-head answering to it; in this head put thin plates of
• lead, so as to stand somewhat erect, without falling, all around the hollow part of the ledge. Put vinegar into the body; set it in a sand-heat,
• put on the head with its lead-plates, apply a receiver, and distil with a
• gentle fire for twelve hours; then leave off, and let all cool for twelve
• hours: the plates, being now gently dried, grow white, or appear covered with a white powder, which being brush'd off with a hare's foot is
• called ceruse, or white-lead. If the operation be several times repeated,
• the whole body of the lead will be turned into the like perfectly insipid,
• scentless white powder: the vapour of the vinegar, raised in the operation,
• condenses into a whitish, turbid, sweet, nauseous, styptic liquor, called the
• vinegar, or solution of lead.

(a) See *Memoir de l'Acad. Roy.* vol. II. pag. 52.

Hence we see how easily lead is dissolved by a very mild acid, and soon changed from its malleable state into a loose powder, or brittle scaly plates. But the distilled liquor, impregnated with dissolved lead, is a true solution of lead, which being inspissated affords the true salt of lead. This operation is continually made in lead exposed to the air, that abounds with acids; whence coverings of lead, that are exposed thereto, resolve into a white calx; and this the sooner, the more the air abounds with acids. If the same operation be performed upon iron or copper, these metals also are dissolved on their surfaces; the iron into a red calx of iron called rust, and the copper into a green substance, called verdigrease; the iron into a gold-coloured liquor, and the copper into one that is perfectly green. The ceruse, thus prepared, is likewise compounded of the acid of vinegar, and the dissolved body of the lead; but the acid is here latent, after the same manner as we saw in iron. This ceruse is of use in watery, ulcerous, running sores, or diseases of the skin, being sprinkled thereon. If this fine powder be drawn along with the breath into the lungs, it causes a violent, and almost incurable or mortal asthma. If received into the mouth, and swallowed along with the spittle, it occasions inveterate distempers in the *viscera*, intolerable faintings, weakness, pains, obstructions, and at length death itself. These terrible effects are daily seen among those who do any work in lead, but principally among the makers of white-lead. Let men, therefore, beware of this poison, which, being both without smell and taste, proves the more pernicious as it is the less discovered, and does not shew itself till it has destroyed the body. Hence we learn, also, how easily lead may be demetallized, and turned to a calx; and this appears upon all experiments. If lead be melted over a gentle fire, in a clean unglazed earthen vessel, it runs pure, like clean quicksilver, but soon grows dark upon its surface, and gathers a skin, which, being carefully taken off with an iron ladle, proves a kind of calx: now, again, the surface appears white, and again generates a skin that may be taken off, till at length the whole body of the lead is changed into this calx, which also is poisonous. This calx, and the former ceruse, being long calcined, and stirred over the fire, at length increase in weight, and turn of a bright red colour: and the like is found of lead-ore long-calcined. In the smelting of copper there rises a scum, which chiefly consists of lead; and if of a colour betwixt red and yellow, it is called litharge of gold; if paler, the litharge of silver; tho' both of them are nearly the same thing, and of the same virtue: lead-ore does not much differ from the former. Hence the same lead may exist under various colours, gravities, masses, and forms, and may be dissolved in the same liquors, and thus afford the same productions; nor is it of much significance, whether ceruse, litharge, red-lead, or lead-ore be thus corroded by vinegar; for in each case the same salt of lead is produced: they have all of them the same medicinal drying virtue, and poisonous quality. Red-lead gains considerably in weight from the fire. This may, perhaps, be owing to the acid of the fewel imbibed by the lead from the fire (a).

(a) See Abr. Boyle, vol. II. p. 390. §. 7.

PROCESS CLXXII.

The vinegar of lead.

1. **B**OIL ceruse in a tall bolt-head, with twenty times its weight of strong distilled vinegar, in our little wooden furnace, often shaking the vessel for four hours; then let all cool, strain off the pure liquor, add more distilled vinegar to the remainder, repeat the operation as before, and continue thus till the ceruse is almost dissolved; mix the several solutions together; they will be found to have lost the sharpness of the vinegar, and to have become sweet, nauseous, and styptic: this is called the vinegar of lead, as also virgins milk; because it cures red spots, pimples, and little ulcers in the face. If this vinegar be filtered, and distilled with a gentle fire to a fourth, there comes over a nauseous water, that is not acid, but of a disagreeable and particular odour. All the acid of the vinegar is retained below, in the resolved ceruse. Let it be preserved under the title of vinegar of lead; and it is to be esteemed of the same virtue as the vinegar of litharge.

2. If instead of ceruse we take the litharge of gold, or silver, red-lead or lead-ore, reduce them to powder, and boil them with vinegar as above; they will all afford the same undistinguishable vinegar of lead. This only is particular of it, that when cold it filters with difficulty, as then blocking up the paper; but when hot it runs thro' easier.

3. When fresh distilled vinegar is poured to this inspissated solution, and boiled, and again reduced almost to the consistence of honey, the vinegar distilled off loses much of its acid virtue, leaving the acid part in the metallic liquor; the part that floats above, being somewhat oily, unctuous, and saccharine, is called by the name of oil of lead, and consists of the metal and the vinegar. The oftner this addition of vinegar is repeated, the more unctuous the liquor becomes, and the harder to dry.

The use.

Hence we have a new method of calcining, and dissolving a very ponderous metal, and bringing it into a liquor. Here we see a new taste and odour produced, by acid and metal; and an attraction and separation of the acid by the metal, till it is fully saturated, and impregnated. This vinegar of lead long preserves uncorrupted the bodies of animals that are plunged therein, or penetrated, and dried therewith; it coagulates the animal juices, and preserves them from putrefaction; if diluted and rubbed upon the skin, it cures breakings-out, redness, inflammations, and the erysipelas; it gives a whiteness and beauty to the skin, but proves pernicious to the body; at length occasioning a consumption, as appears by many melancholy examples. If the inspissated oil of lead be mixed with an equal quantity of oil of roses, it makes a white balsam, highly commended by the surgeons.

PROCESS CLXXIII.

The salt of lead with vinegar.

1. **I**NSPISSATE a quantity of the vinegar of lead in a low glass-body, with a very wide mouth, till it becomes almost as thick as oil; set it in a quiet cold place, and a whitish grey mass will shoot to the bottom, in small, erect spiculæ; pour off all the liquor, and with a gentle fire slowly dry the remainder, which will now be white like sugar, and is called the sugar of lead.

2. Dissolve this sugar of lead in fresh and sharp distilled vinegar; let it stand to depurate; inspissate the liquor to the thickness of oil; set it in a cold quiet place, and there will shoot at the bottom thick solid crystals, perfectly resembling the form of vegetable candy-sugar, and having nearly the same taste.

3. If these crystals be again dissolved in fresh distilled vinegar, and the solution be depurated by standing, then inspissated by a soft fire to the thickness of oil, a liquor will be obtained which can hardly be dried, and rendered hard by a small fire, but it remains somewhat fixed, and may be liquified like wax, with a gentle heat. The oftner this impregnation is repeated with fresh vinegar, and the matter dried, the more fixed it becomes in a small fire, so as not to smoke, but easily run. If now it be committed to a moderate heat, and afterwards suffered to cool, but whilst it remains fluid, it be poured into another cold vessel in the cold air, it strongly coagulates in the pouring, and concretes into fine threads like cobwebs, perfectly resembling silver-thread, and affording a very agreeable sight. This was published as a secret by a Jesuit, tho' somewhat disguised in the delivery (a).

4. As soon as this body, coagulated into threads, is exposed to a greater heat, it presently runs again, so that it may again be poured out. And if this resolution and inspissation be carefully and patiently repeated, each time separating the fæces, and then if the matter be long digested with a gentle heat, till it grows thick, and concretes, a mass is at length formed, which to the unwary eye resembles silver. *Isaac Hollandus* deserves to be read upon this subject, where he speaks concerning the stone from lead. The process also may be continued at pleasure, by those who desire to see unusual appearances of bodies.

The use.

The production is called the sugar, salt, magistery or vitriol of lead. It shews how a fermented vegetable acid may be combined with lead, into a substance soluble in water. It is astringent, styptic, and presently coagulates the blood: being dissolved in water it affords the vinegar of litharge, good against inflammations, when externally used. Internally it is recommended

(a) *Lewth.* Abridg. of Philos. Transact. vol. III. p. 325.

for a safe remedy against spitting of blood, bleeding at the nose, making bloody urine, the *gonorrhoea*, the *fluor albus*, and the like, as also for a mollifying remedy against the acrimony of the blood; but I never durst make trial of it, because I never saw it successfully used by others; and because I know there is scarce a more deceitful and destructive poison than this lead, which presently returns to ceruse, as soon as the acid is absorbed from it, by any thing it may meet with; whence it afterwards proves an exceeding dangerous and almost incurable poison to the body. If the salt of lead be gradually distilled in a retort, and at length urged with a violent fire, there comes over a fat inflammable spirit, perfectly changed from the nature of the vinegar employed; and there remains at the bottom a substance like glass, which, when urged by a strong fire, penetrates almost all the vessels that are known, vitrifying all bodies, and carrying them thro' with it, except gold and silver.

PROCESS CLXXIV.

The salt of lead with spirit of nitre.

1. **P**UT an ounce of granulated lead, ceruse, litharge, or red-lead, into a tall bolt-head; pour thereon fifteen ounces of spirit of nitre, or *aqua fortis*, diluted with ten times their weight of water; there arises a great ebullition with a white froth; which being over, set the glass in our little wooden furnace to boil for five or six hours. Let the liquor rest, and cool, then filter it, and distil it to a pellicule; a nauseous but not acid water will come over; put the remaining liquor in a cold place, and there will shoot white, solid, and very ponderous crystals, that do not run in the air, but continue solid; they are of a sweetish taste, and more austere than those of the preceding process: the liquor also, after the solution, or both before and after the crystallization, has a saccharine sweetness, like the salt. 2. If fresh *aqua fortis* be poured to this salt, so as to dissolve it, and the liquor be again inspissated, an oil of lead may thus also be prepared, which coagulates with difficulty, but gradually fixes, so as to run like wax, with a gentle heat. 3. This salt being dried, and thrown upon live coals, does not take flame, but crackles violently in the fire, and flies all around, with great danger to the by-standers; but if reduced to fine powder, it may be melted in a strong fire.

The use.

Hence we have a new method of producing a metallic salt, and its oil; a sweet taste, from an acid and an insipid body; a glass from a metal; and of shewing that spirit of nitre will not make an inflammable salt with every metal, as it does with silver. The salt here has the same virtues as that of the preceding process, but is more sharp and astringent.

The Practice of CHEMISTRY.

PROCESS CLXXV.

The salt of lead treated with alcalies.

TO two ounces of the crystalline salt of lead, made according to the hundred seventy-third, or hundred seventy-fourth process, thoroughly dried, and reduced to fine powder, add four ounces of oil of tartar *per deliquium*; set them in digestion, where the longer they stand the better; then add an ounce of sal-ammoniac, mix them well, and digest again in a close vessel; pour back the saline liquor that comes over in the digestion, and digest again; which being twice or thrice repeated, thoroughly dry the matter by a gentle fire, and expose it to a moist air, that it may dissolve; dry it again, and distil it in a coated glass-retort, with degrees of fire to the highest that sand will give, into a large receiver, containing a little fair water. Three kinds of matter will thus come over, which seems surprizing, whilst another of a particular nature, and strangely changed, remains at the bottom of the retort.

The use.

Many very particular things are learnt from this experiment, and such as are pleasant to behold; for the metal thus successively opened and dissolved by opposite salts, then coagulated and dissolved in the air, is highly changed, opened, subtilized, divided and separated from all that which is not purely mercurial or metallic, and may thus exhibit its pure metallic mercurial part, separated from the rest; if the industry of the operator can reach so far.

PROCESS CLXXVI.

The calx of the vitriol of lead.

TAKE the vitriol of lead, made according to the hundred seventy-third, and hundred seventy-fourth processes, dry it thoroughly with a gentle fire, grind it to fine powder, put it into a glazed earthen dish, set it over the fire, and keep it continually stirring with a tobacco-pipe, till it yields no more fumes with a great heat; a fine, and almost insipid powder will thus be obtained, which is another calx of lead, made in the moist way.

The use.

All the acid which was united with the lead, in the form of the vitriol of lead, is here again separated from it by the fire, except that part, which intimately adhering thereto, does not appear externally, and was therefore much more closely united with it in this operation.

PROCESS CLXXVII.

The balsam of lead with expressed vegetable oils.

1. **P**UT granulated lead, any calx thereof, ceruse, litharge, or red-lead, into a glazed earthen vessel; add to it twice its weight of any expressed oil; then gradually raise the fire, and the lead will begin to melt at the bottom before the oil boils; but if the fire be gradually increased, so as to make the lead boil, the body of the lead, or calx, will begin to disappear, and mix so intimately with the oil, as to make a true balsam, which, by longer boiling, may be brought to a substance that is solid in the cold, semi-metallic, will melt in the fire, and is ductile. 2. If, instead of lead, or its calx, we use that calx prepared in the hundred seventy-sixth process, or the salt of lead, first dried, and treat it with expressed oil in the manner above delivered, the like balsam will be obtained as from the true metal, and the oil.

The use.

Hence we see, that true and very ponderous metals may, by the means of fire, be dissolved in vegetable sulphur, and so mixed, as to lye perfectly concealed therein; whence we are often ignorant whether metals are concealed in certain bodies or not; how wonderfully they may be disguised: and how often they may proceed from matters not thought to contain them; when they have been often falsely supposed to be obtained from them by transmutation: all these particulars admonish us to be cautious of the impositions of the fraudulent alchemists. These emplastic preparations of lead are of use to strengthen and warm the parts, whereto they are applied; they also discuss, mollify, and absorb acrimonious humours; in particular, they are excellent for lining vessels designed to contain water; for if red-lead be boiled in oil to a proper thickness, and be exactly spread over a stone-wall made almost red-hot, so as intimately to penetrate and stick therein, it will cause the wall to resist water, as well as if it was built with cement. This mixture we use to prevent worm-tubs from leaking.

PROCESS CLXXVIII.

The balsam of lead with distilled vegetable oil.

GENTLY dry the sugar of lead of the hundred seventy-third process, put it into a tall bolt-head, and add to it four times its weight of the ætherial oil of turpentine; boil it for some time, which is easily done, if the glass, with this mixture, be put into a vessel in which linseed oil grows just hot enough for the purpose, which happens long before the linseed oil itself will boil; thus the oil of turpentine will almost wholly dissolve the sugar of lead, whereby the balsam is obtained.

The use.

This process has the same use with the former.

PROCESS CLXXIX.

The glass of lead.

1. **MIX** two parts of red-lead with one of clean sand, reduced to fine powder, by grinding them long together; then put them into a clean crucible, set in the fire, so that the matter may melt, and continue in fusion for some time, till, when examined by dipping a tobacco-pipe therein, what sticks thereto appears transparent; then pour it out upon a marble; a brittle, yellow, transparent, inodorous, insipid mass will be thus obtained, that proves hard in the cold, and melts in the fire; whence it is called glass of lead. This matter, when fused in the fire, passes thro' all the known vessels, as water thro' a sponge, and converts almost all bodies into glass, with itself in fusion, carrying them thro' the pores of the vessels, except gold and silver. In order to make the mixture of the red-lead and sand sooner run into glass, some add nitre, and others sea-salt, and keep the crucible in the fire till the salt is melted. 2. If the fumes of lead be put into a crucible, and urged with a gentle fire, successively increased, the vinegar flies off, and the matter is so changed, as to run into a yellow glass, at the same time that wonderful, pleasing colours appear in the middle, like those of the rain-bow, or the peacock's tail. 3. If lead itself be long kept melted in the fire, it becomes drossy at top, which increases, till the lead is almost wholly converted into the same kind of matter; and this being again urged with a strong fire, turns of itself into glass: but this is a laborious operation, and requires much caution: the easiest method appears to be the following. 4. Take four parts of red-lead, one-part of sand, and two parts of dry decrepitated sea-salt; grind them together, the longer the better; put them into a close-covered crucible, melt them all together, and suffer the whole to rest; the salt will be found melted in a glebe at top, and the glass below, when the crucible is broke, and should be separated from the rest for the purposes of metallurgy, where it is extremely useful. 5. These glasses being mixed with a little powdered charcoal, and melted in the fire, easily turn to lead again.

The use.

We have here a wonderful change of this metal, (by means of fire, and the discharge of a metallic, highly poisonous vapour,) from a perfectly malleable state, to an extremely brittle and true glassy matter. Whence we see how wonderfully, and under what various forms, metals may lye concealed, and how easily they may again appear. And hence, perhaps, metals vitrify in the fire, after being separated from a certain sulphureous part. This seems to appear from the making of the glass of antimony, and other

other experiments. And upon restoring this sulphur, the metallic form begins to return, as we see in many instances, especially in lead (a). This glass of lead is the true test of metals, and destroys every thing in the fire, except gold and silver, which it leaves untouched, without any diminution of their weight. And upon this foundation depends the whole art of assaying and refining, which is of so great use in civil affairs: and let thus much suffice for lead. Whoever would know more of the subject, may consult Boyle, Bobn, Homberg, and Geoffroy. But let it be carefully remembred, that the fume, the powder, and all the parts of lead are carefully to be avoided, as highly poisonous.

PROCESS CLXXX.

The solution of pure silver in spirit of nitre, or aqua fortis.

1. TAKE an ounce of silver, refined with ten times its quantity of lead, upon the refiner's test; melt it in a clean crucible, and directly pour it into fair cold water, eight inches high, in a cylindrical vessel; the silver falls into it with a hissing noise, and is scattered about in the water in grains: it is now called granulated silver. Put an ounce thereof into a clean urinal-glass; then take two ounces of *aqua fortis*, put thereto a grain of refined silver, and if it be soon perfectly dissolved, so as to leave the liquor limpid, the *aqua fortis* was good, and fit for this purpose; but if not dissolved, or the liquor appears turbid, the *aqua fortis* is not genuine, or proper for this purpose. The first kind of *aqua fortis* is called proof *aqua fortis* by the refiners. Pour two ounces of this proof *aqua fortis* upon an ounce of granulated silver, contained in the urinal-glass; the liquor immediately begins to move, bubble, grow warm, fume and hiss about the surface of the silver, and then becomes spontaneously hot, briskly agitated, sends out red fumes, and dissolves the silver, so that it perfectly disappears. A transparent colourless liquor is thus obtained, of an exceeding sharp, bitter, and caustic taste; a little of a very black powder always remains at the bottom of the glass. This powder is pure gold, which either always adheres to silver, or else, perhaps, is easily produced from the lead in the fire, as Mr. Homberg conceives; and being incapable of dissolving in *aqua fortis*, is thus precipitated from the solution: pour off the clear liquor into a clean glass, and intitle it the *Solution of silver*. 2. If, instead of *aqua fortis*, spirit of nitre be employed, the solution is performed quicker and stronger, but otherwise in the same manner; for *aqua fortis*, or spirit of nitre, prepared either with bole or oil of vitriol, scarce seem to differ, except in being more or less acid; but if the least particle of common salt, or sal-ammoniac, should accidentally have fallen into the spirit of nitre, or *aqua fortis*, or have been mixed with them in the distillation, or afterwards, they will not dissolve the silver.

(a) See Memoir. de l'Acad. Roy. an. 1709. p. 218, &c.

The use.

If this solution proves limpid, the silver was pure; but if greenish, it contained some portion of copper, and is not fit for the following experiments: the silver here united with the acid of the spirit of nitre, keeps suspended in the water; a drop of the liquor, applied to any soft warm part of the body, instantly burns and eats it: whence at once touching, it eats down the callous and hard lips of ulcers, separates the corrupted part, and presently takes away marks, spots, warts, and small cancers. It may be diluted with pure water, without growing thick or precipitating; but if the water contains the least saline matter, the whole will presently grow turbid. This solution, well weakened with water, is highly detergent; but stains the skin it touches with a black spot, that cannot be got out, before the scarf-skin falls off. Hence we see how the ponderous body of silver may lye concealed in a light, limpid liquor: but it may be discovered by its violently bitter taste.

PROCESS CLXXXI.

The vitriol of silver.

1. **T**O the solution made in the preceding process, gradually put single grains of pure silver, so long as it will dissolve them. When the last grain remains perfectly undissolved, set the saturated solution in a cold place; it will presently begin to form little, thin, white plates, lying over one another, as if composed of triangular needles like nitre. If the liquor be poured off from them, we thus obtain the crystals, salt, or vitriol of silver, which may be dried, but are so sharp, that they cannot safely be touched. 2. If the former solution be not further saturated with silver, but inspissated a little, so as to lose about a tenth part, and then be set by for some time, the silver will concrete at the bottom of the glass, in a solid form, into white crystals, in other respects like the former, but much sharper, as being here saturated with more acid. And these also have a much greater caustic virtue.

The use.

We here see the particular, and mutual attraction betwixt silver and the acid of nitre; as silver scarce unites with any other acid: for tho' it turns black, it does not dissolve with them. This vitriol of silver is a most immediate caustic, and leaves a black spot upon any part of the skin it touches ever so slightly; and this spot cannot be got off but by the scaling off of the skin.

PROCESS

PROCESS CLXXXII.

The lunar caustic, or lapis infernalis.

1. TAKE potters earth that is well wrought, and not very moist, make it into a solid cube, and perforate the upper surface thereof perpendicularly, with a conical stick, almost to the bottom. Let the internal surface of the whole be smooth, lest the matter poured in should come out rough. When as many of these holes are made as are necessary, press the upper part of each with the finger, into a wide spherical cavity, the middle whereof ends in a conical hole; for thus the matter may be easily poured in. 2. Then take a little glass-dish, or urinal-bottom, and put into it the first crystals of silver of the preceding process; set the glass, without any fear of breaking, upon burning coals; the crystals will discharge an unctuous fume; which ceasing to rise, whilst the matter flows in the glass, pour it carefully into the conical cavities made in the cube of clay; it will enter with an hissing noise. If the matter in the glass should chance to grow stiff, set it again over the fire; and thus pour out all the prepared silver into the hollow moulds. 3. As soon as the whole matter is grown solid, immediately break the clay, and take out the conical sticks of silver; wrap them up in hot paper, and dry them thoroughly therein; then wipe their surface, with a hot and dry hare's foot, and thus immediately put them into a clean glass, that is to be well stopped with a cork: and thus an excellent *lapis infernalis* will be obtained for surgical uses, and may be kept perfect for many years.

The use.

The acid of the spirit of nitre, in the glass over the fire, loses its water in the form of fume; and also that part of its acid which remained above what a certain proportion of silver could retain; but the silver detains a certain proportion of the acid with itself, so as not to fume, but remain fixed, even in fusion over the fire: this acid, retained in the body of the pure silver, forms a solid mass, in which, perhaps, the acid is the purest and strongest that can be prepared. When this acid, adhering to the silver in a solid form, is exposed to the air, it attracts the moisture thereof, and so dissolves. The whole of this *lapis infernalis* will also dissolve in water, from whence, by the means of copper, all the silver may be recovered, insipid, inodorous, unactive, no way acid or corrosive, but pure, metalline, and unchanged. It is strange therefore that the acid should so long adhere to the surface only of the principles of silver, without changing them, so as that the nature of the metal may be entirely recovered unhurt. This *lapis infernalis* is a most powerful caustery, and by a bare touch instantly burns the parts of a live body to an eschar, under which nature raises an inflammation that separates the crude eschar, and leaves the part pure; so that by repeated touches with this matter, all superficial, foul, fungous ulcers and cancers are excellently cured. Hence skilful chirurgeons highly extol the virtue of this stone; and physicians.

physicians also learn the wonderful power of an acid, when collected and fixed. If given internally in this form, it is an immediate corrosive poison; and therefore never to be used in this manner. I have known it prove pernicious to the artist that prepared it.

P R O C E S S CLXXXIII.

The silver pill of Boyle or Angelus Sala.

1. TAKE an ounce of pure nitre, and dissolve it in pure distilled water; then take an ounce of the pure crystals of silver, made according to the first direction, under the hundred eighty-first process; dissolve them in thrice their weight of fair water, so that the liquor may be perfectly limpid; mix the two solutions together; they will thus make an homogeneous, uniform, and apparently simple liquor, without precipitating the silver, but uniting perfectly with the nitre. Put the pure liquor into a clean urinal-glass, and set it over a clear fire in a place free from dust, till the water, which will thus be almost pure, exhales, so as to leave a pellicule. Set the glass in a cold quiet place, well covered to keep out the dust; crystals, like nitre, will thus shoot. Pour off the remaining liquor, and exhale as before; the silver and the nitre will be thus joined in the simple form of crystals: let this mass be gently dried. 2. Let there be at hand the bottom part of an urinal-glass, into which put the crystals of silver, and nitre, first dried in paper; set this glass on the fire, so as to prevent the matter from running by the too great heat or nearness thereof, and permit it only to dry or to fume; keep it constantly stirring with a stick of glass, so that it may every way be exposed to a strong fire, but so as not to melt; that it may be dried and freed from the sharp acid that adhered to the mass, and easily rendered it caustic; but if the fire should melt it, then the acid, being more closely united, fixes the corrosive virtue, which by this gentle calcination is separated. Let this calcination be performed with caution, for a long time, keeping the matter continually stirred, till no more fume rises, tho' the fire be now considerably strong, and almost able to melt the matter: for at last, after the heat has separated all this acid, there is no harm if the mass be fused, because all the external acid is now driven from it; and thus the purging silver will be prepared, of an extremely bitter taste, and should be kept in a dry close vessel.

The use.

It is a wonderful and secret art to unite silver with nitre: hence the pretended alchemists can, by this means, conceal silver in a large proportion of nitre, as ten times its quantity for example; and this nitre being projected, in an equal quantity, upon melted lead, gives an increase of one tenth part in silver, which remaining upon the test, will deceive the ignorant, as if a tenth part of the lead was here turned into silver. The way to discover the cheat is to dissolve the mass of nitre and silver in ten times its quantity of pure

pure distilled rain-water, then put a polished plate of copper into the liquor; for thus every particle of the silver will immediately be precipitated to the copper, and bottom of the vessel, and thus be obtained perfectly pure from the nitre and spirit of nitre. If, therefore, any salt be pretended to, for the making of silver, let it be examined in that manner. Take this dried mass, consisting of the salts of silver and nitre, reduce it to a fine dry powder, and it will be of an extreme bitter taste, but by no means so caustic as before. If a little of it be applied to ulcers, it acts like *lapis infernalis*, only much milder; and if two grains of it be fine ground with six grains of loaf-sugar, in a glass-mortar, then mixed with ten grains of the crumbs of bread, and formed into nine pills, and these be taken by a grown person upon an empty stomach, drinking after them four or six ounces of hot water sweetned with honey, they will purge gently, and bring away a liquid water, that often deceives the patient, as coming away almost without being perceived. It kills worms, and cures many inveterate ulcerous disorders; it relieves in the dropsy, and purges without griping; but it must not be used too freely, nor in too large a dose, for it always proves corrosive and weakening, especially to the stomach; which inconvenience is remedied by the rob of juniper.

PROCESS CLXXXIV,

Inflammable silver.

TAKE an ignited piece of Dutch turf, after it ceases to smoke, place it with its upper flat surface, parallel to the horizon; make a little cavity in the middle of its surface, and therein put a drachm of dry *lapis infernalis*, it will here immediately melt, glow, take flame, hiss, and shine briskly in every respect as nitre. After the flame ceases, pure silver will be found in the hollow, as much in quantity as was dissolved in making of the *lapis infernalis*, and may thus be taken out with a pair of forceps, without loss of weight.

The use.

This excellent experiment shews the physical manner wherein acids do but superficially adhere to silver; and the manner wherein acids operate when united to metals, whilst surrounding their metallic mass, they arm the ponderous principles thereof with *spicula*. It shews the immutability of silver dissolved in an acid, and the various ways wherein it may lye concealed, yet still have its action; it also shews the difference of potable silver, while existing in a saline form, by means of an adhering acid, from that potable silver of the adepts, where the principles of the silver are supposed converted into a fluid that will mix with the juices of the body, and cannot be reduced to silver again; but chiefly it hence appears, that the acid spirit of nitre, adhering in a solid mass to the silver, is as inflammable along with a combustible body, as nitre itself. This seems to happen in silver alone, which is unchangeable, by the spirit of nitre. Hence also we see one way whereby silver may be obtained pure from other adhering mat-

ters, by bare burning. The acid here acts neither upon the mercurial part of the silver, nor its fixing sulphur: and many more particulars of this experiment might be enumerated.

PROCESS CLXXXV.

The recovery of silver, when dissolved in spirit of nitre.

DISSOLVE an ounce of pure silver in spirit of nitre, dilute it with twenty times the weight of distilled rain water, heat the solution in a cylindrical glass-vessel, and put therein polished plates of copper, the smooth surfaces whereof will every where begin to be covered with a grey colour, and at length appear as if thick set with down. The liquor that before was aqueous, and colourless, will now gradually turn more and more green, in proportion as the down upon the copper-plates grows larger. If a plate be shook, the downy covering falls off from it to the bottom, and another like the former presently comes on; the liquor grows greener, and the plates grow less. The downy covering being again shook off, a fresh one grows; and this happens till at length no more of the copper dissolves. Now leave the vessels for six hours at rest, afterwards shake off all the grey-coloured downy matter from the plates; decant and filter the liquor; it will be of a beautiful green colour, sharp, and intirely cupreous; the plates will be much diminished in bulk and weight. Let the matter at the bottom be washed in several hot waters, till it becomes thoroughly pure, then dry it over the fire; it will be a fine shining silver powder, and yield nearly all the silver employed, pure, insipid, and mild, without any acid; nor will it contain the least copper.

The use.

This is a method of calcining silver to a fine powder, which cannot easily be obtained so subtile by any other means. This powder being ground with mercury, easily affords an amalgam, which is otherwise so difficultly obtained, and not without a great loss of the quicksilver. If this powder be melted in a crucible, it restores the same silver that was employed. Hence, therefore, it appears how superficially the acid of the nitre adhered to the silver, since the whole of this acid is so easily attracted by the copper from the silver, without any remainder. If the liquor of this operation be viewed with a microscope, it appears plainly that little particles of silver are violently carried along with the acid of the nitre up to the copper-plates, from all the points of the solution. But when these *spicula* arrive at the smooth surface of the plate, the acid is attracted to the particle of the copper, whilst the particle of the silver, deprived of its acid, rests upon the surface of the copper; and being there increased by others coming to it in like manner, at length a soft downy case is composed: and this attraction is so exquisitely performed, that not the least particle of silver remains in the former solution. Hence it appears, that copper more strongly attracts the acid of nitre than silver does; wherefore this action consists in attraction, and a remaining

of the acid from the body of the liquor; for the acid passes thro' the pores of the copper, leaving behind the particles of the silver now set free, and unable to enter: there is scarce a more beautiful sight than this with a microscope. The acid of the nitre remains unchanged in the silver, and is collected perfect in the copper, from whence it may again be obtained.

PROCESS CLXXXVI.

Luna cornea.

1. **T**O the pure solution of silver made with spirit of nitre, according to the first direction of the hundred and eighty-first process, and diluted with four times its quantity of pure water, let fall, by a drop at a time, in a capacious glass vessel, a small quantity of a strong and warm solution of sea-salt in water. At the instant the drop falls in, the whole liquor grows white and surprizingly thick, without any effervescence. Continue thus dropping in, and shaking the glass, till the liquor no longer continues turbid; then let it rest: a gross white matter will fall to the bottom in a large quantity. Let the limpid liquor at top be poured gently off, and drop into it a little hot solution of sea-salt; if it grows thick no longer, the operation is well performed, but otherwise some silver remains behind, which requires to be separated. Pour clean hot water upon the white precipitated matter, and wash it till it becomes perfectly insipid, then boil it in an urinal with a little fair water, shake them together, and pour the whole into a paper filter, where the water will pass thro' and leave the white matter behind, which is to be dried with a gentle fire, and preserved as the subtil calx of silver precipitated with sea-salt from spirit of nitre, or *aqua fortis*; it will weigh more than the silver employed by nearly a fifth part, on account of the salts, which adhere thereto. 2. Put this calx of silver into a clean crucible, set it in a fire of fusion till it melts, which it easily does; when melted, pour it out on a marble: it appears a ponderous, shining, opaque, brown mass, that breaks brittle with some degree of tenacity, whence it is called horny. It contains all the silver employed, and at the same time the acid of the nitre and sea-salt, wonderfully concreted therewith, so as not to be easily separated; for by endeavouring with a violent fire to drive away the spirit, which is so easily done in the *lapis infernalis*, the greatest part here becomes volatile, and the remainder is scarce recoverable into silver, but remains changed by the admixture of the salts, so intimately united, and fixed, as not to manifest themselves by any saline property. If one part of pure silver, calcined according to the hundred eighty-fifth process, be mixed with two parts of mercury-sublimate and distilled in a glass-retort, with a strong sand-heat at last, almost the same perfect *luna cornea* will remain at the bottom of the retort. And if instead of salt, the spirit of sea-salt were used to the solution of the silver, the *luna cornea* would be perfectly the

The Practice of CHEMISTRY.

same. Mr. Boyle says, that silver being precipitated from spirit of nitre with oil of vitriol, then washed and fused, will become a true *luna cornea* (a).

The use.

This experiment is of infinite use, and shews how small a difference in a physical circumstance may often occasion a great difference in the thing physically produced; for silver mixed with *aqua regia* does not unite with the acid thereof; but if when silver is dissolved by spirit of nitre, sea-salt is added thereto, tho' it thus only makes an *aqua regia*, yet it presently occasions the acid of the *aqua regia* to unite intimately with the silver, and produce strange effects. For if two parts of the precipitated calx of silver be well ground with one part of regulus of antimony, and distilled with a sand-heat, there comes over a pure butter of antimony, equal in weight to the antimony employed; whilst the silver remaining at the bottom, always affords true gold upon the reduction. Hence we may be certain that the weight gained by the calx of silver, is owing to the *aqua regia* fixed therein, because it here goes into the mercurial part of the antimony; whence it is no wonder, that those eminent chemists *Becher*, *Boyle*, *Homberg*, and *Stahl*, have so much regarded the concealed arsenical nature of the metals and salts in this experiment. Who could conceive that the exceedingly insipid body of *luna cornea* held a fifth part of the highly corrosive acid of *aqua regia*? Hence we see what a particular power sea-salt has upon metals, how covertly it may adhere to, and again be recovered from them without loss of its virtues. Hence also we see how strangely metals may be disguised and concealed; and again, how gold may be obtained from a matter in which the assay-masters could not, by all their art, discover any: and hence the adepts have said, that nature has only placed perfection in salt and gold; and hence we may also learn to guard against the fraudulent practices of those who craftily mix this calx of silver with nitre, or throw it into melted lead, and thus pretend an increase of silver or gold. But our present design does not lead us farther into this subject. It is certain that the industry of Mr. *Homberg*, by the means of tartar, quick-lime, sal-ammoniac, and the white of eggs, has from half a pound of silver obtained, as he declares, three drachms and fifty grains of running mercury: and so much of the nature of silver for the present. *Luna cornea* neither dissolves in *aqua regia*, *aqua fortis*, nor the fire.

P R O C E S S CLXXXVII.

Tin dissolved in aqua regia.

1. **M**IX with *aqua fortis*, or spirit of nitre, a sixth part of sea-salt, or sal-ammoniac, or spirit of sea-salt, and thus an *aqua regia* is obtained, which dissolves gold, and not silver. If *aqua fortis* also be drawn off

(a) Origin of forms, p. 203—209. Some mistake here of the author, see *Abr. Boyle* vol. I. p. 537. §. 9.

from ^{nitre} sea-salt, or spirit of salt from ^{nitre} nitre, by distillation, thus also an *aqua regia* is obtained. Again, if two parts of nitre, three of vitriol, and five of sea-salt, be distilled together, as in the making of *aqua fortis*, this affords an excellent *aqua regia*; which therefore we see consists of a mixture of nitre and common salt. 2. To a quantity of this *aqua regia* contained in an urinal-glass, add a little tin, and a violent dissolution arises; continue till as much tin is dissolved as possible, and the solution will appear thick or oily. If the solution be diluted with twenty times its quantity of water, or more, the tin will be precipitated; which being perfectly washed in water, and then dried, affords a white powder, or magistery of tin. 3. Tin, put into *aqua fortis*, makes a violent effervescence; when the tin dissolving and swelling appears in the form of a thick soap, or the white of eggs.

XIXXIX The use.

This is a particular manner of solution; the liquor is in some measure bitter, and therein approaches to silver. The calx, thus prepared, is given by many physicians, as a particular remedy in hypochondriacal and hysterical cases; but I do not admire it, as there are safer for the same purpose. When duly mixed with pomatum, it affords a famous cosmetic, in case of an ulcerated skin. It is difficult, with the utmost violence of fire, to reduce it to tin again. It appears by this experiment, that tin of all the metals, dissolves with the least proportion of acid. It is surprising that tin, dissolved in *aqua regia*, does not fume; yet if mixed with twice its weight of mercury-sublimate and distilled in a retort, it affords a liquor at first that will smoke perpetually, and exhale all away.

PROCESS CLXXXVIII.

Copper dissolved in distilled vinegar.

1. IF plates of pure copper be put into a glass alembic-head, and treated as the plates of lead under the hundred seventy-first process, the distilled vinegar will come over in form of a green liquor; so that if the operation be long enough continued, all the metal will be thus dissolved. The liquor so prepared and filtered, being inspissated over a gentle fire, becomes green like an emerald; and the least part of a drop proves vomitive. It is of an ungrateful nauseous smell. The plates being dry, afford a rust or *crocus* of copper, but not the true verdigrease, which is only made at *Montpellier*, by a very particular treatment of copper-plates with the vapour of red wine, that has been digested with the husks of grapes after pressing. Hence this latter menstruum is scarce acid; but oily, fat, and unctuous. 2. If the common verdigrease be put into a bolt-head, and boiled with pure distilled vinegar, till a tincture is procured, and this being poured off, and new vinegar added, and the whole process repeated, till the last vinegar be no longer tinged, there remains a large quantity of insoluble matter at the bottom, which shews that it is not dissolved copper alone

The Practice of CHEMISTRY.

alone that makes this verdigrease. All the tinctures being filtered, and distilled, till only one fourth remains, afford a strong solution of copper, that shoots into green crystals, which, when too dry, and deprived of their acid, turn black. See Process 53.

The use.

This process serves to shew the solubility of copper, the origin of its rust, verdigrease, and the blackness that easily tarnishes copper; with the way of discovering copper concealed in silver, by the greenness it easily communicates to acids. The solution is of a wonderful emetic and purgative virtue: watery, spongy, running, sanious, virulent ulcers, being touched with this liquor, are quicken'd, contracted, dried, and cleansed.

PROCESS CLXXXIX.

The solution of copper in sal-ammoniac.

MIX three parts of sal-ammoniac with one of pure copper-filings, add four parts of fair water, in a cut glass body, dry the whole to a paste by a gentle fire, and again dissolve it in the air: repeat the process several times, by which means an almost entire solution of the copper will be obtained. Then boil the mixture with water; filter, and inspissate the liquor a little, which will thus become a pure tincture; and if artistically crystallized, it affords beautiful saline crystals of copper.

The use.

Hence we see the relation betwixt salts and copper. The liquor, here obtained, is a famous anti-epileptic for children; a few drops of it given in mead, upon an empty stomach, and followed with gentle exercise, purges a little, gives a nausea, but wonderfully improves and excites weak and relaxed stomachs, carries off water, and kills worms; and by this means proves curative in certain kinds of ill habits, and the epilepsy.

PROCESS CXC.

Copper dissolved in aqua fortis.

PUT common aqua fortis, or spirit of nitre, into an urinal, and by degrees throw in a little fine filings of pure copper; there immediately arises an ebullition with red fumes; all the liquor instantly appearing of a beautiful green. Continue thus, till the last part thrown in does not increase the greenness; let the liquor be purified by standing, and by filtering, and afterwards inspissate it to an half.

The use.

Hence we learn the action of spirit of nitre upon copper. The solution is emetic in a small dose: it kills all insects, and if largely diluted with water, it

it readily destroys lice, fleas, and crab-lice; in ulcers it has the same effects, as above-mentioned, of copper dissolved in vinegar, but requires to be cautiously used.

PROCESS CXCI.

Copper dissolved in aqua regia.

THROW the filings of copper into *aqua regia*, or spirit of salt, and proceed as in the last process, and the effect will be the same.

The use.

Aqua fortis and *aqua regia*, therefore, equally dissolve copper. Hence all those opinions, of the difference of these two, are insignificant in assigning the reason why one of them dissolves gold, and the other silver. The particular relative natures of things can only be learnt by experiments; it is therefore unsafe arguing that metals are similar, because they are dissolved by one and the same menstruum. Genuine chemistry draws no such conclusions, but avoids generals, unless collected from pure observation.

PROCESS CXCI.

Copper dissolved in volatile alkali.

PUT a drachm of copper-filings into a clean glass, pour thereto twelve times their weight of the best alkaline spirit of sal-ammoniac; stop the glass and shake it often; a blue and at length a beautiful violet tincture will be obtained. Pour this off, and add fresh spirit, and thus, by degrees, nearly the whole substance of the copper will be dissolved, and turned into tincture. If copper-filings be moistened with thrice their weight of the oil of tartar *per deliquium*, and then digested, and resolved; and this be several times repeated, and the mixture afterwards boiled, filtered, and inspissated, a like solution, but of a fixed nature, will be obtained.

The use.

This beautiful alkaline volatile tincture holds the body of the copper dissolved. If drank in a morning fasting, with a glass of mead, beginning with three drops, and daily doubling the dose to the fourth time, when twenty-four are to be taken, walking gently after it, and then continuing the same dose of twenty-four drops, for some days, it proves opening, warming, attenuating, diuretic; it is a powerful and ready remedy, by means whereof alone, I have cured an hydropical patient, labouring under a confirmed *ascites*, by procuring such a discharge of urine, that it run out as if it had been from an open pipe; so that the integuments of the emptied *abdomen* might be wrapt into folds: and this person perfectly recovering, with the use of a proper restorative, dry diet, long remained healthy. Encouraged by this

this success I, with a juvenile confidence of having found a cure for the dropsy, tried the same medicine on others, but found it failed me; and thus I was taught that the assistance of nature is required in such successful cures. Dropsies are of many kinds, some curable various ways, others incurable. The same tincture, however, deserves to be commended in all disorders from an acid, watery, weak, cold, phlegmy cause. From our processes upon copper, it appears to be easily dissolved in any acid, alcali, or neutral salt, whether manifest or concealed; for if copper-filings be digested in expressed oil of olives, the distilled oil of turpentine, or the like, which always conceal a covert acid, the copper thus turns them of a green colour, and gives them the same virtues for chirurgical uses: and thus much for copper.

PROCESS CXCHII.

The purification of quicksilver.

1. **T**AKE mercury bought of the company at *Amsterdam*, put it into a piece of leather, cut round, and formed into a little bag; tie this bag close at top with a strong pack-thread, and squeeze it strongly over a large glazed dish; the mercury will be thus strained pure, thro' the pores of the leather. Lastly, squeeze the bag tight, that the whole may come thro': I have not found this mercury to leave any foulness behind.

2. I have distilled two pounds of this mercury in a clean glass-retort, with a sand-heat, into a glass-vessel, fitted to the receiver, and open at both ends, so as to have its lower plunged under water; the whole body of the mercury thus comes over without leaving any faeces, even tho' the distillation were thrice repeated in the same retort. For still I had two pounds of mercury, a very small quantity of a thin fine red powder, of scarce any weight, remaining in the retort, but no feculency; so that the mercury, even by this tryal, was pure; which is a principal recommendation of this commodity.

3. Take a pound of the same mercury, put it into a retort, and add to it two pounds of clean lime slacked in the air; distil in a retort with a sand heat, and a pound of mercury will be obtained again; so that even thus no feculency is found, which, if there were any, would certainly appear in this method.

The use.

These are the common ways of purifying mercury, and fitting it for the following operations; and this is the method I always use: and hence we see the volatility of mercury, the degree thereof, and the purity of the company's mercury at *Amsterdam*: but for the alchemical purification, we may perhaps speak of it elsewhere.

PROCESS

PROCESS CXCIV.

Quicksilver dissolved in aqua fortis.

TAKE four ounces of pure mercury, and six ounces of aqua fortis, put them into a clean urinal, surrounded with a small fire, that the whole may grow warm; the mass of quicksilver will begin to bubble at the bottom, and consume, whilst red fumes and a heat are produced. When the mercury is dissolved, add a little more, so that some part may remain undissolved, even in the heat; pour off the liquor, when cold, into another glass; the quicksilver will be dissolved into a pellucid, uniform liquor, even tho' examined by the microscope. It is of an austere taste, smells like spirit of nitre, or aqua fortis, and is as colourless as water.

The use.

Hence we see that the very opaque body of quicksilver becomes pellucid by aqua fortis, or spirit of nitre; and tho' so many times heavier than the menstruum, hangs suspended in a liquor fourteen times lighter than itself; still remaining quicksilver and unchanged, only surrounded with the acid, as will appear hereafter. It is here so equably distributed in the fluid, that if a single drop thereof be artificially examined, it will appear to contain a proportionable part of mercury, in respect of the whole liquor, from whence it was taken; which is a particular that deserves the consideration of chemists, and those who understand hydrostatics. Whence we see that the mercury is here very finely divided, that the acid is uniformly united with each particle of the mercury, and that this acid, equably united with the mercury, is intimately distributed therewith, amongst its watery part. This solution is violently caustic, so that it can scarce be touched; as burning all the parts of the body with violent pain and heat: whence it becomes effectual in extirpating warts. If a small part of a drop touches the skin, it presently turns it purple. Neither aqua regia, nor spirit of salt easily dissolve mercury; yet corrosive mercury sublimate is a true salt of mercury, dissolved by the spirit of sea-salt, or aqua regia; for it produces all the true effects thereof; and if put to salt of tartar, regenerates sea-salt. And if first precipitated, it may be dissolved in aqua regia; but it can, alone, be sublimed into a mercurial salt along with sea-salt.

PROCESS CXCV.

The vitriol of quicksilver.

1. IF so rich a solution be made of quicksilver in aqua fortis, or spirit of nitre, as that no more will dissolve therein by heat, and the solution be poured into a cold glass, there spontaneously shoots to the bottom a saline, white, transparent matter, from whence the liquor being poured, this matter remains sharp, moist, saline, soluble in water, and not safe to be touched.

The Practice of CHEMISTRY.

* touched. 2. If the remaining liquor be inspissated to a half, and set in a
 * cold place, crystals like the former will shoot. 3. But if one part of
 * quicksilver, along with two of pure decrepitated sea-salt, reduced to
 * powder, be distilled in a glass-body, with a strong fire, for five or six
 * hours, and when cold, the glass be broke there will be found a solid, dry
 * mercury, sublimed in the form of vitriol; and the common mercury-
 * sublimate is a true mercury of vitriol, tho' semi-volatile.

The use.

Quicksilver, therefore, is reduced to an imperfect vitriol, with spirit of nitre, and to one that is perfect with spirit of salt; but with spirit of nitre, it is fixed; and with spirit of salt, volatile: which makes a considerable difference. The vitriol is sharpest, that is made with spirit of salt.

PROCESS CXCVI.

The white precipitate of mercury.

* **T**AKE a solution of mercury, made so strong that *aqua fortis*, or the
 * spirit of nitre can dissolve no more; whence there remains no more
 * acid than what is requisite to dissolve that proportion of mercury; add
 * twice the quantity of pure water: then have at hand a strong and hot
 * solution of sea-salt; let this fall, by a drop at a time, into the solution of
 * mercury; upon which the liquor will immediately become white, opaque,
 * and turbid, where the solution of sea-salt fell; after shaking the vessel, a
 * white precipitate will fall to the bottom, and a limpid liquor float above.
 * After the solution of the sea-salt no longer makes the liquor turbid, let
 * the vessel rest for some time, till all the white powder is fallen; then
 * gently pour off the limpid liquor, till all this white powder is separated.
 * Shake the remainder along with the white powder, and put it into a paper
 * filter, set in a glass funnel; a limpid liquor will come away, which may
 * be added to the former: and a white powder will remain on the paper.
 * To this pour several hot waters, till what comes thro' be at length as in-
 * sipid as it was poured on. After which the white powder will remain
 * almost tasteless in the filter: dry the paper with its powder by a gentle fire;
 * and afterwards keep it separate, under the title of the *white precipitate of*
 * *mercury.*

The use.

The acid spirit of nitre, here attracted into the mercury, and now dissolved in the water, becomes an *aqua regia*, as soon as it is mixed with the sea-salt; but *aqua regia* does not dissolve mercury, like spirit of nitre; therefore the mercury is let go by the former solvent, and falls into a precipitate to the bottom. The water washes the *aqua regia* from the powder that externally adhered to it; yet in this powder some of the acid still adheres to the body of the mercury, whence it has a particular virtue, as may be shewn by many experiments. The powder, thus prepared, is perhaps the best remedy
 style="text-align: right;">hitherto

hitherto afforded by mercury, for internal use. It operates effectually, and with considerable safety. If ground with thrice its weight of loaf-sugar, it makes what may more properly be called a mercurial *Panacea*, than perhaps other laborious preparations of mercury; for, however mercury may be treated, its medicinal virtue principally depends upon a certain quantity of acid adhering to its metallic part. This acid virtue, if it abound and appear externally in the mercury, acts with more violence, but with less safety: if more sparingly added, and more united to the mercury, it acts more slow, more mild, and safe; and this is the case with our present precipitate. If the saccharine powder, above mentioned, be given in the quantity of nine grains to a person fasting, it purges, vomits gently, kills worms, opens and cleanses the vessels concerned in preparing the chyle, resolves phlegm, and thus cures many distempers, such as the gonorrhœa, itch, venereal ulcers, &c. If this dose be several times repeated daily, it raises a kindly salivation. If a drachm of this white precipitate be well mixed with an ounce of pomatum, or the ointment of roses, it makes an excellent and safe unguent in cutaneous disorders, and proper for curing the itch, breakings out in the face, and inveterate ulcers. It is therefore no wonder if it should be substituted in the room of the boasted *panaceas*. If this powder be put into a glass, set over the fire, and kept constantly stirring with a glass rod, and thus be long and gently calcined, it becomes so mild, as scarce to purge, vomit, or salivate, and therefore acts very gently when taken internally; and in this form the chemists commend it as a diaphoretic, and corrective: but thus treated, it is so mild as to have little curative virtue. If a little of this powder be rubbed upon a warm and polished copper-plate, it presently gives it the appearance of silver; but this soon goes off again in the fire.

PROCESS CXCVII.

Red precipitate of mercury.

1. TAKE a pound and a half of the liquid solution of mercury, made according to the hundred ninety-fourth process, put it into a glass retort, that will hold twice the quantity, apply a receiver, and distil in our little wooden furnace, with so small a fire as not to make the matter boil, yet bring it almost to dryness; there will remain a solid, white ponderous mass at the bottom, which is extremely corrosive and fiery, so that it cannot be handled. There sticks up and down to the sides of the glass, somewhat of a red, yellow, or white matter; the mercury then beginning to dry, in a manner that is pleasant to behold. The liquor driven over is a weak and considerably pure spirit of nitre, fit for the cleansing of glasses, and other uses. This operation, therefore, is a kind of coagulating of mercury into vitriol. 2. Put the retort into a sand-furnace, and lute on a large receiver; distil with a gentle fire, so that the drops may follow each other, at the distance of four or five seconds. Continue thus till red fumes begin to rise; then immediately apply another large and clean receiver; the liquor that comes over is a stronger and purer

spirit of nitre, to be kept for its particular uses. Urge the remainder with degrees of fire, and fumes will continue, and at length very red ones will fill the receiver; then keep up the fire, to the utmost, for two or three hours: there will be found in the receiver a yellow and exceeding strong spirit of nitre, that will afford yellow fumes for years, if directly confined in a clean glass: and by this means, an exceeding strong spirit of nitre may be procured, as being in some measure rectified; tho' it thus in some respect changes its nature, as it will not so well take flame with distilled oils. All being now cool, there will remain at the bottom of the retort a solid mass, of a shining red colour, between which and the neck, as also in the neck itself, will be found a matter of very various and beautiful colours; as white, yellowish, yellow, greenish, reddish, and highly red. Break the retort carefully, take out the red matter in the belly of the glass, and separate it cautiously from that which appears less red on the surface; for this latter is very corrosive: keep the red part by itself under the title of the red precipitate of mercury. 3. The chemists admiring this shining mercury, and the remarkable fixedness thereof, which was before volatile, imagined that, by repeating the operation, they might convert it into a fixed gold. They therefore poured fresh spirit of nitre to it, drew it off again, and, by often repeating the operation, thought to obtain gold, which *Sylvius*, in his posthumous works, asserts to have been thus done: but this is incredible to the cooler chemists. *Paracelsus* in the preparation of his precipitate, directs the spirit of nitre to be often drawn off from the mercury.

The use.

Hence we learn the changeable nature of mercury, from fluid to solid, from volatile to fixed, from mild to corrosive, and from white into almost all kinds of colours. But however it is prepared with the acid of nitre, yet it may be recovered, in its native form and original weight, unchanged, if it be distilled by the retort, along with fixed alkali, quicklime, or iron filings. This precipitate, which goes by the name of *Vigo's* precipitate, is sharp and corrosive, occasioning pain, and producing an eschar, when externally applied; and hence, afterwards, it always occasions a thick white pus, and thus cleanses the lips and bottoms of putrid ulcers, and disposes them to heal. It is dangerous to give internally, as inflaming the *viscera* by its caustic virtue, and occasioning anxiety, pain, vomiting, purging, griping, and operating also by urine and sweat. If given in too large a dose, which should never exceed three grains; or if too often repeated, it occasions a salivation, with all its symptoms; and thus cures many distempers, that are not easily curable any other way. It is more violent and dangerous than the white precipitate. *Paracelsus* and *Helmont* shew how to mitigate it, by several times distilling alcohol upon it; and thus indeed it becomes milder, by losing much of its acid: but at the same time it requires to be given in a larger dose. They also corrected it with the same success, by distilling from it the water of the white of eggs. Others dissolve it in strong distilled vinegar by boiling, then strain and purify, and by several times distilling the vine-

gar

Get off, render the powder more mild: but there seems to be little gained by all this; white precipitate being already the thing here required. In short, the acrimonious acid adhering to the mercury, causes it to operate in a very small dose; and the more this acid is in it, and the more external to the mercury, the more violently it acts, and *vice versa*. If this precipitate be put into a thin hollow glass dish set over the fire, and continually stirred with a tobacco-pipe, it will change of a deeper colour; and if long continued thus, it becomes so much the milder, so as at length scarce to act at all.

PROCESS CXCVIII.

Mercury-sublimate.

DISSOLVE half a pound of mercury in a sufficient quantity of *aqua fortis*, according to the hundred ninety-fourth process; carefully inspissate it to a white dry mass, according to the first direction under the hundred ninety-fifth; take also ten ounces of decrepitated salt, and as much common vitriol calcined to whiteness. Grind these two salts for a long time separate, in a glass mortar, with a glass pestle, in a dry and warm place; then mix them together, and carefully mix in the mercury among them. Put the powder into a bolt-head, of which it may fill only a third part; cut off the neck of the glass, so as to leave only about seven inches thereof above the body: set it in a sand-furnace, so as that the bottom of it may touch the iron pot; and let the sand rise exactly up to the surface of the contained matter. Apply a very gentle fire, and increase it by very small degrees, till a vapour exhales out of the mouth; which vapour is to be avoided, as highly pernicious to the lungs. When all the moisture is perfectly evaporated, stop the mouth of the glass with paper, and increase the fire, till the pot be red: a corrosive mercury-sublimate will rise to the sides of the glass in white transparent crystals; let the glass cool, then break it, and separate the sublimate carefully from the fæces, and soft powder at top, and keep it in a dry glass. For the method used at Venice, consult Tacbenius in his *Hippocrates chemicus*.

The use.

The white mercury, here employed, contains *aqua fortis* mixed in among it: the white calx of vitriol, mixed with sea-salt, enters this salt, and drives out the spirit; and whilst these two act upon the mercury, by the means of fire, there is made an *aqua regia* by the spirit of nitre, contained in the mercury, and the spirit of sea-salt, set free by the acid of vitriol. The phlegm is first discharged by a gentle fire; the strong acid part of the *aqua regia* unites with the mercury, and corrodes it; but this *aqua regia* is of the nature of sea-salt. The spirit of sea-salt fixes the quicksilver, not like the spirit of nitre, but rather makes it semi-volatile; and hence the mercury is sublimed, and is a true solid dry vitriol of quicksilver, that remains consistent in the air. The basis of this vitriol is pure quicksilver, and the other part the

the strongest spirit of sea-salt, that can any way be obtained; so as here to appear in a solid form. With respect to this acid spirit of sea-salt, the preparation is a *lapis infernalis* of mercury, and a most violent corrosive, presently converting all the parts of the body it touches, into an eschar, that soon falls off; whence it consumes obstinate callosities in ulcers, as also warts, and indurated glands. That eminent chirurgeon *Johannes a Vigo* was acquainted herewith, and hence composed his troches of minium, which are an incomparable remedy for consuming scrophulous tumours, and eradicating them by suppuration. The taste of this vitriol is abominably austere. A grain of it dissolved in an ounce of water, affords an excellent cosmetic, if cautiously used. It proves poisonous to all cutaneous insects by bare lotion. If a drachm of this solution be softened with syrup of violets, and drunk twice or thrice a day, it performs wonders in many reputed incurable diseases: but it requires to be cautiously used, by a prudent physician, and should not be ventured upon, unless the method of managing it is known. This mercury, when mixed with metals, and semi-metals, has very excellent and inimitable effects, even such as would surprize a chemist. It wonderfully changes silver itself (a). Certainly this mercury-sublimate is a key, that serves to open numberless chemical secrets. By means of it, perhaps, some proportion of silver may be converted into gold, that could not before be found therein (b). Hence also is obtained the *menstruum peracutum* of Mr. Boyle, and other things. No chemist will repent of the labour he employs upon this sublimate. We see that *aqua regia* will dissolve mercury better than any *aqua fortis*, provided it be first dissolved in the latter; and the spirit of salt will sublime it, tho' before fixed with spirit of nitre. If, according to the direction of Mr. Boyle, this mercury be sublimed with an equal weight of sal-ammoniac, it will afford a wonderful salt.

PROCESS CXCIX.

Turbith of mercury.

1. PUT four ounces of pure quicksilver into an urinal-glass, pour thereon eight ounces of rectified oil of vitriol, heat them gently and slowly; then put the glass upon burning coals, that the matter may boil gently, with care to avoid the fumes; to which purpose the operation should be performed under a chimney, that the vapour may go off without coming at the lungs. The quicksilver, running at the bottom of the oil of vitriol, will thus begin to dissolve. Continue the same degree of heat, till all the mercury is dissolved; the mass will be white like snow; calcine it, with the same degree of heat, to dryness, or till it fumes no longer; it will be an exceeding white and snowy powder, but intolerably sharp, so as not to be touched: it is called the white calx of mercury, made with oil of vitriol. The operation succeeds in this manner, but scarce in those commonly directed. 2. Grind the dry and hot mass in a dry

(a) See Abr. Boyle, vol. I. p. 253.

(b) See above Process 186.

mortar,

‘ mortar, to fine powder; have at hand a glass vessel full of clean hot water,
 ‘ at least twenty times the weight of the mercury; throw the calx into it;
 ‘ at that very instant the white powder falls thro’ the water to the bottom,
 ‘ and acquires a grateful lemmon colour. Shake the vessel for some time,
 ‘ that the powder may be well mixed with the water; then let all settle;
 ‘ decant the liquor into another glass, wash the remaining yellow powder
 ‘ with several hot waters, till it becomes perfectly insipid, then dry it tho-
 ‘ roughly with a gentle fire: this beautiful yellow powder is called turbith
 ‘ mineral. 3. Let the first liquor poured off, stand for some time, then
 ‘ strain, and inspissate it to a third part; it will be a *mercurial water*: for
 ‘ if a little oil of tartar be dropped therein, a reddish precipitate will fall to
 ‘ the bottom: and the liquor may be kept under that title.

The use.

Thus the strongest oil of vitriol, united to mercury, makes a white fixed powder, that will endure a very strong fire; as being much more fixed than one would imagine. We see there are different effects of different acids, with regard to the colour. The white colour here is not changed with the most violent fire, tho’ it was easily with the spirit of nitre. This white powder, however, being calcined, becomes exceeding corrosive, and thence poisonous. Here we see a new colour immediately arise, in a particular manner, upon the bare contact of water; for if this white powder be properly prepared, and laid in the open air, it soon grows yellow on its surface, by attracting the moisture of the air. This seems to be the powder, with which, when rightly prepared, *Paracelsus* performed wonders; as appears from his little Hospital Chirurgion: and this is sufficiently attested by *Oporinus*, who declares he has frequently been employed in making it. It may be rendered milder by burning spirit of wine upon it, after the manner of the ancient chemists, who by this means took away from their metal-line calces the salts that externally adhering thereto rendered them too sharp, so that only the salts intimately united, might remain behind. The prudent *Sydenham*, who is a cautious and sparing commender of the chemists, gratefully acknowledges that by means of this medicine, diseases, otherwise incurable, might be cured (a). *Mr. Boyle* relates, that by a small dose hereof, used as a sternutatory, the whole body has been changed, and even cataracts cured. A woman at *Paris* is also said to have herewith cured persons given over. Hence it seems an extraordinary medicine in stubborn and obstinate cases; but it requires a skilful physician, and should not be used when safer remedies may suffice. It is serviceable in the dropsy, as well as in the venereal disease, and also in the most obstinate diseases of the glands. *Helmont* says, that oil of vitriol is here converted into alum, barely by the contact of mercury; but this is either speaking improperly, or not justly: but when that excellent author directs the fire of the vitriol of copper to be poured upon *Vigo’s* powder, and thence distilled, for preparing the secret cathartic of *Paracelsus*, if I understand him right, it makes this me-

(a) See his piece upon the Venereal Disease.

dicine : for if the *fire of the vitriol of copper* be the strongest oil of vitriol ; as soon as this is poured upon red precipitate, it immediately renders the spirit of nitre volatile, causes it to fly off from the fixed mercury, and soon after, supplying its place, produces the calx of mercury as above. If the water of white of eggs be several times distilled from it, this takes away the acid externally adhering thereto, and renders the powder milder, tho' it will still operate sufficiently ; which is an effect seldom procurable any other way. But if by fire, any thing else be here understood of a more subtle nature, I can fix no other meaning to it ; but by comparing *Helmont* with *Paracelsus*, I suspect it is no more than what I have said. Metals alone have little effect upon the body, except by their bulk, figure, and weight ; but by addition of salts, especially the acid kind, they acquire new properties, often strange ones, and very different, according as the acids are more fixed therein, or adhere more externally. In the form of vitriol they act very violently ; but if calcined in this form, the calx grows gradually milder, and by a long continued strong calcination, which drives out the acids, they become mild, tho' before exceeding sharp, as we see happens in turbith : and thus their operation becomes milder, and at the same time proportionably less effectual. Those chemists and physicians, therefore, are mistaken, who having found that this turbith performed extraordinary things, but operated violently, endeavoured to mitigate its virulence ; which indeed may be easily done, but not so as to have the same effects, when mitigated as before. The ways of mitigating the acrimony, are by taking away the acid, by washing the preparation with water, by frequently distilling pure water upon it to dryness, by pouring alcohol upon it, by distilling several parcels of alcohol upon it to dryness, by grinding it along with more metallic matter, as in the preparation of *mercurius dulcis*, by the addition of alkaline salts, which absorb the acids, by grinding the matter with chalk, crab-eyes, testaceous powders, or the like absorbers of acids, by a long continued calcination, and lastly, by fixation with a fire gradually increased, from a moderate heat to the highest that glass will bear.

PROCESS CC.

The fiery oil of mercury.

TAKE mercury calcined with oil of vitriol to a dry snowy calx, as in the preceding process, suffer it to cool, put it into an urinal-glass, and pour thereon an equal quantity of oil of vitriol, boil as before almost to dryness, with great care to avoid the fumes : it now dries much more difficultly, and requires a longer time, and a much stronger fire. When the powder is dry, put the same quantity of oil of vitriol thereto, and proceed as before ; at length it will scarce dry by a long continued and strong fire, but begin to cease flowing, and to grow rigid like fixed oil ; being highly sharp, caustic, and not to be touched, like the *ignis gehennæ* of *Paracelsus*. By this means the mercury is so fixed with the oil of vitriol, as not to go off with the violent action of the fire.

This experiment serves to shew the method of impregnating, saturating, and incrating metals by acids, to any degree; and also of fixing volatile mercury by them, so far as is possible: but no metal is hence to be expected; for in whatever manner mercury is fixed with acids, yet it is again recoverable in its pristine state, by grinding it with twice its weight of iron-filings, and distilling it in a glass retort, with the highest degree of a sand-heat.

PROCESS CCI.

The æthiops of mercury.

TAKE a drachm of flowers of sulphur, and three drachms of mercury, grind them together for a considerable time in a glass mortar; the mercury will begin to disappear, and the sulphur become of a grey colour. Continue rubbing till the quicksilver entirely disappears, when the powder will grow black; and the colour will be the deeper, the longer the grinding is continued: and thus may æthiops be prepared in any quantity. This powder, by standing, concretes into a solid black mass, that may again by grinding be easily reduced to powder.

The use.

Hence we see how easily mercury is united to crude and cold sulphur, barely by mechanical triture; yet so as to become closely united therewith, and not easily separable again. The powder is scentless and insipid, not at all sharp, nor easy to be thoroughly mixed with any thing. When given internally, it cannot enter the absorbent vessels, the lacteals, or lymphatics, but passes directly thro' the intestinal tube; where it may happen to destroy worms, if it operates luckily. They are deceived who expect any other effects from it; at least, I myself could never find them. I am afraid it is unwarily given in such large quantities to children, and persons of tender constitutions; as being a fossil mass foreign to the body, and unconquerable by the nature thereof; and should be the more suspected, as it there continues long sluggish and unactive. It does not raise a salivation, because it cannot come into the blood. Who knows the effects of a substance, which so long as it remains compounded, seems not more active than any ponderous insipid earth? But we certainly learn from this experiment, that the acid of the sulphur is not here attracted from the oily part, into the mercury, because there hence arises no acrimony, but the whole remains an uniform, insipid, sluggish mass.

PROCESS CCII.

Facitious cinnabar.

1. TAKE a tall earthen vessel, that widens upwards, put into it four ounces of flowers of sulphur, then melt the sulphur over a gentle fire; the make and height of the vessel thus preventing it from taking flame. Then take quicksilver heated, but so as not to fume, and pour a little thereof into the melted sulphur, which will thus presently grow viscous; stir it continually with a thick tobacco-pipe, and continue pouring and stirring, till thrice the quantity of quicksilver, in proportion to the sulphur, be thoroughly mixed in therewith. At this time, there commonly arises a great hissing, with thick red fumes, and the matter takes flame with a noise; put a tile upon the mouth of the vessel, let all cool, and the mass will be found black. 2. Put this mass, which is like the æthiops of the preceding process, into an *Hessian* body; closely lute on a head with a mixture of clay and lime, or else invert another body on the former: set it in a sand furnace, so as to touch the bottom of the iron pot; bury the vessel in sand, a little below the matter; raise the fire gradually to the utmost; at first a little insipid water will rise, then a few whitish flowers, and at length a black matter. When the fire has been continued at the greatest height for three hours, let all cool; a compact matter will be found sticking to the sides of the body, and appearing black on its outward surface: brush off this blackness with a hair's foot, grind the mass, and it will appear of a fine red colour; it is called facitious cinnabar: a little feculent matter will remain at the bottom of the body.

The use.

Thus in the first place æthiops is here made by fire, as it was in the preceding process by trituration. Cinnabar is a mixture of mercury and sulphur united by the fire, in the form of a simple fossil; which is found natural in many mines, and is like the facitious, without much difference. It has nearly the same virtue, in the body, as æthiops. *Crato* called it the magnet of the epilepsy; but I never saw it produce any great effects. If it be mixed with purgatives, then, like æthiops, it is driven quicker thro' the intestines, with the success above-mentioned of æthiops. It is mixed with red cosmetics in the form of pomatum; it is used in fumigations against venereal ulcers in the nose, mouth, and throat, with little, and often with bad success. The mercury may be revived very pure from the cinnabar, by grinding it with twice its weight of iron-filings, and distilling it in a retort, with the strongest heat of a sand-furnace, into water.

PROCESS COIII.

Mercury amalgamated with lead, and other metals.

1. **M**ELT clean lead in an iron ladle; add to it an equal weight of heated mercury; stir them together with an iron rod, then let them cool; it thus makes an uniform mass of a silver colour, somewhat hard, but growing softer and softer by trituration. Put this mass into a glass mortar, grind it, and mix therewith any quantity of mercury at pleasure, which will unite with it as salt with water. 2. The amalgam of tin is made exactly in the same manner; and this also may be diluted by the addition of more mercury. 3. Take a solution of pure copper made in *aqua fortis*, and so strong, that the *aqua fortis* could dissolve no more of the metal; dilute the solution with twelve times its quantity of fair water, heat the liquor, and put into it polished plates of iron; the copper will be precipitated in the form of a powder to the bottom, and the iron be dissolved. Continue thus till all the copper is fallen; pour off the liquor, and wash the powder with hot water, till it becomes perfectly insipid. Then thoroughly dry the powder, and grind it, in a glass mortar, with an equal weight of hot quicksilver. Thus an amalgam will be made of the copper; and may also be diluted by the addition of more quicksilver. Whoever tries to make the amalgam of copper any other way, will find it difficult. 4. We above observed in the processes upon silver, that an amalgam of that metal might be made in the same manner, after it is precipitated pure from *aqua fortis*. 5. Dissolve pure gold in *aqua regia*, till the menstruum will take up no more, and dilute the solution with twelve times its quantity of fair water; put polished plates of copper therein, and a gold-powder will precipitate to the bottom, and to the copper; keep the liquor warm till it no longer appears turbid upon the addition of more copper. Shake the plates, that all the gold may fall to the bottom; pour off the liquor, wash the powder of gold, dry it, grind it in a glass mortar with quicksilver, and thus it will become an amalgam, which may afterwards be diluted with more mercury. 6. Or take a mass of gold and silver purified with lead, and by means of proof *aqua fortis* separate the silver; wash the black powder of gold remaining at the bottom, and grind it hot, and dry, with quicksilver; and it will presently make an amalgam, which may be diluted at pleasure. Every amalgam is white, whatever may be the metal it is made from.

The use.

In the ways above described, an amalgam may be made of any metal without loss, except iron: the other ways are attended with a great loss of the quicksilver, and danger from its fumes. Hence we see that mercury is the true solvent of metals. Metals, made into an amalgam, may be mixed, confounded and secretly concealed among one another. I believe that alchemy depends upon this solution of metals by mercury. Hence quicksilver is sophisticated with

lead; but the fraud is easily discovered, by exhaling a grain or two thereof. And, perhaps, hence it is, that mercury coagulates in the fume of melted lead; which has been ascribed to a fixing property in that fume, and to a wonderful fixing metallic spirit, even by *Paracelsus* and *Helmont*. The method is to melt lead, and when it begins to grow cold, or before it sets, to make a little cavity with a stick therein, and in that cavity to lay a little cold quicksilver, which will there soon become solid; but this seems to happen from the lead, which still remains hot, being received into the mercury, and thus amalgamating, and hardening therewith. For if a little of the mercury, thus fixed, be put into a crucible, and urged with a melting heat, the mercury flies off. The fraudulent alchemists often secretly conceal gold or silver, in mercury; then project it on lead, and thus pretend to make gold or silver: but if a little of this mercury be put into an iron ladle, and held over the fire, the mercury flying away, and leaving the metal behind, discovers the cheat. The making of amalgams is the foundation of the art of gilding both in gold and silver.

PROCESS CCIV.

Metals washed with mercury.

TAKE an amalgam, grind it in a glass mortar, the longer the better; it will begin to grow black; pour fair water upon it, and grind it therewith; the water will become black and turbid; then directly pour this off, and grind the remaining amalgam with fresh water, which will be discoloured in like manner. Continue to grind, and pour on fresh water, till at last it comes off as pure as it was poured on; the amalgam will now remain as bright as silver. All amalgams, thus treated, afford more or less of this black matter, but that of gold the least. The black powder, when dried, is found neither metal nor mercury. The other amalgams will scarce ever thus become perfectly clean, so as to leave no blackness in the water.

The use.

Hence pure quicksilver, mixed with metals, does so unite with them, as to discharge somewhat that was latent in one, or in both. If a large quantity of this powder be procured from gold and silver, the matter of both these metals remains the same, without increasing or diminishing their weight; in which case, therefore, the powder must proceed from the mercury. This is a matter of deep speculation; of which I cease to speak more at present, intending to consider it at another opportunity.

PROCESS

PROCESS CCV.

The solution of gold.

TAKE four parts of *aqua fortis*, and one part of pure sea-salt, mix them together, they will make a yellow-coloured liquor. Put into it, as contained in a glass-urinal, one part of pure gold in thin plates; set the glass over the fire to heat, that the gold may dissolve: then by degrees throw in two or three grains more of gold, till at length no more can be dissolved with heat. Pour out the solution, and it will be of a gold-colour. If nothing black remain at the bottom, it is a sign no silver was mixed with the gold; for whatever silver there had been in it would have fallen to the bottom, in form of a black powder. This is the solution of gold, which is made with all kinds of *aqua regia*, however differently prepared, as we have above related and explained.

The use.

Hence we see the reason of the term of *aqua regia*. If this liquor touches the skin, it stains it of a purple colour; it is caustic, and if taken internally, highly poisonous; if precipitated with a fixed or volatile alkaline salt, all the gold falls to the bottom. If the powder be perfectly washed with water, then very carefully dried, with a heat of eighty degrees, it will be found increased in weight, with respect to the gold employed. When this powder, thus gently heated, comes up to a certain degree, it suddenly goes off, and vanishes, with a loud report; and hence is called *aurum fulminans*. This is a surprising phenomenon, that can scarce be accounted for *a priori*, nor by the analogy it has to any thing else: certainly they who have hitherto endeavoured to explain it, have laboured in vain. Those who have made explosions with this powder in a large glass vessel, have recovered a little fine dust of gold. They who have given it internally, as promising themselves extraordinary effects from the great price of the secret, have thus occasioned violent pains, gripings, and other disasters. The discovery, therefore, of new and extraordinary things in chemistry, may have little relation to the service of medicine.

. PROCESSES upon SEMI-METALS.

I. Upon the saline Kind.

PROCESS CCVI.

The analysis of vitriol into spirit, oil, and coccothar.

1. TAKE eight pounds of the common green vitriol of *Goflar*, put it into two earthen long-necks, each containing four pounds; cover them with a tile, set them upon a hearth, and surround them with fire, that the whole may grow gradually hot: the vitriol will thus begin to fume, and upon increasing the fire, and bringing it nearer, to melt; and upon making the fire still stronger, to thicken and turn grey. Then surround the long-necks on all sides so with fire, that the matter may grow yellow, and begin to appear red at the sides of the vessels. Now let all cool; the long-necks will be crack'd; take out the matter, and beat it to powder; it will be of a yellow colour. This is the calcination of vitriol, in order for distilling the spirit, and oil thereof. This operation ought to precede, otherwise the distillation would be tedious; on account of the time required to draw over the aqueous phlegm; or else the receivers would crack, on account of that phlegm arising hot into them; and the distilling-vessels also burst, as being forced by the melted matter. Hence the matter is to be calcined only so long as till it ceases to melt in the fire. In this first part of the operation the eight pounds of vitriol are reduced to five. 2. Put these five pounds of calcined vitriol, first bruised, into a strong long-neck, as described in the distillation of spirit of nitre, and spirit of sea-salt with bole. Let the long-neck be large enough to hold double the quantity; set it in the furnace, as was before directed for procuring the spirits of nitre, and sea-salt; when properly placed in the furnace, and the wall is built up, apply an adopter to the mouth of the long-neck, luting it on carefully, with a mixture of clay and lime; wrap a wet linen rag about the other end of the adopter, and apply thereto a very capacious glass-receiver, so as exactly to fit, and so as the adopter may not reach above two inches into it. Let this receiver rest horizontally upon a bench, so that the axis both of the receiver, the adopter, and the long-neck may lye in the same horizontal plain, lest otherwise the neck of the adopter, or the receiver, should be pressed against: lute the second juncture in the same manner as the first, and put linen rags about it, spread with the same luting; and thus leave the vessels for twenty-four hours, that

that the luting may grow dry. 3. Make the fire with all the cautions delivered under the hundred forty-first, and hundred forty-fourth processes; a white fume will first rise, and the receiver grow warm: keep the fire up in this state for six hours; oily veins will afterwards run down the sides of the receiver; and in this state again continue the fire for six hours; then for six hours longer keep it up to its utmost height, that the long-neck may be thoroughly red hot: a thick oil will thus come over. If the vapour should pass thro' the luting, put a linen rag, spread with the same, and well heated, upon the crack; and thus it will be stop'd. Tho' the fire should be ever so long continued, the vapour would not cease to rise, but the produce would not defray the cost; so that I judge eighteen hours sufficient. Now, therefore, let all cool, till the adoptor is but just warm, and the receiver grown quite cold. 4. Have then ready at hand a bottle with a narrow neck, and fitted with a wide glass-funnel; then carefully moisten the rags, and the luting applied to the mouth of the receiver, and take them away gently, with care to prevent the dirt from falling in, the fume from coming out so as to prove offensive, and the glass from cracking, by being moved obliquely. Take it therefore away in a straight line, and avoid the noxious fumes. Cleanse the mouth of the receiver, that no luting may drop in; then pour the liquor out of the funnel into the bottle, stop it up, and set by the receiver for the like purposes. I have usually thus obtained one and twenty ounces of thick, black, strong, and smoaking oil of vitriol. A red, blackish, light, powdery, austere calx remains in the long neck, to the quantity of fifty-two ounces; so that five ounces are lost in the operation.

The use.

And thus the oil or spirit of vitriol is prepared, which has numerous uses in chemistry and medicine; for it is a most powerful, ponderous acid, and a great preservative, tho' itself a caustic: and hence vitriol consists of this, and colcothar, and phlegm. This oil of vitriol will scarce boil without a fire of six hundred degrees. If put into a glass-body, and urged with a sand-heat of five hundred degrees, it yields its wild suffocating spirit and water, then changes from black to limpid, and becomes exceeding ponderous, and fiery; and if poured into a glass wet with water, it produces such a heat as instantly to crack the glass: it attracts water out of the air. If four ounces of this oil be, by a sand-heat, distilled in a little retort, with a long and very curved neck, so as that one drop may follow another at the distance of six seconds, and fall into fair water, contained at the bottom of the retort; as pure and perfect an acid spirit will be thus obtained as oil of sulphur *per campanam*: but this requires a skilful operator. Each drop, when it falls into the water, makes a hissing, as if fire had fallen therein: but if a falling drop touches the glass, it immediately cracks it, as if it were cut with a diamond. If a stronger fire be used, the neck of the retort cracks, the labour is lost, and a pernicious suffocating fume exhales, which ought to be very cautiously avoided. This process is otherwise noble, and of excellent use, as may be learnt from a prudent exercise of chemistry and

and medicine. *Paracelsus* describes the best method of preparing this spirit to be by distilling recent vitriol to dryness, in a vessel of *Hessian* earth; and cohobating the liquor upon the remainder, the oftner the better; at last using the utmost violence of fire: and by this means he promises a liquor serviceable in many cases. The direction is ingenious and artist-like, provided the vessel be kept from bursting by too large a quantity of the dry vitriol. The caution is, to use a little quantity at once, in proportion to the vessel.

P R O C E S S CCVII.

Ens veneris.

1. TAKE the remaining colcothar of the preceding process, put it into a large crucible, cover it with a tile, and set it in the hottest part of the surface, where the fire breaks up in the distillation of the oil of vitriol, and there let it stand ignited the whole time of the operation. By this calcination, it will turn very red; then boil this colcothar in water; keeping it well stirred, in a glass vessel; strain the liquor hot; it will have the taste of vitriol; pour fresh water to the remainder, boil, and strain as before, and continue thus so long as the water, even by boiling, acquires any taste. At length, keep the remaining fine red powder under the title of the dulcified calx of vitriol. If the former pure liquor be inspissated, it will still yield a kind of yellow vitriol; whence we learn how wonderful a body vitriol is, in respect of its fixedness in the fire, even in its saline part. 2. Take an equal part of this dulcified calx of vitriol, and the dried flowers of sal-ammoniac; grind them in a hot glass mortar with a glass pestle, for a considerable time, till they are perfectly mixed, but with care to prevent their growing moist; whence they should be ground on a clear dry day, and in a warm place. Put the powder into a low earthen body, fit on a wide alembic-head, with a wide pipe; apply a small receiver; place the vessel in a sand furnace, so as almost to touch the iron pot; half bury the body in sand, and raise a fire by degrees. There first comes over a sharp, volatile, yellowish liquor, of an intolerable odour, and an exceeding sharp, fiery taste, almost as in the sublimation of iron, in the hundred sixty-ninth process; the method being here nearly the same. The fire being increased, and the liquor drove over; first white, then yellow, and soon after very red flowers will rise: continue the fire for six hours, making it so strong at last, as almost to ignite the iron-pot. Let all cool; there will be found in the head and upper part of the body, a beautiful, red, saline, astringent sublimate, very like the flowers of iron. Let it all be carefully taken out, and directly put into a dry glass. A matter will be found at the bottom, of an austere taste, that easily swells, and in some measure runs in the air: but the production will be different; according as the vitriol was from copper or iron.

Here we see the metallic part of vitriol that remained so fixed in the fire, is rendered volatile by sal-ammoniac. The nature of this iron from vitriol

so calcined, is nearly the same in the flowers, as in the crude iron of the hundred sixty ninth process; and might therefore rather be called *ens martis*, than *ens veneris*. When prepared from the calx of blue vitriol, it then deserves to be called *ens veneris*. And hence we may understand the death and resurrection of metals, mentioned by *Paracelsus*. A small proportion of this sublimate turns a large one of the infusion of galls to ink. Mr. *Boyle* promises great effects from this remedy, in distempers proceeding from a weakness of the solids, as in the rickets, or the like; and it is highly serviceable therein. *Helmont* also in the treatise he intitles *Butler*, greatly commends a like preparation. But as even after the utmost violence of the fire sustained, both in a close and open vessel, there still remains something vitriolic; it is no wonder, that the fumes of vitriol, continually remain, how long soever the distillation be continued: doubtless this wonderful body deserves to be examined.

II. Processes upon the Sulphureous Semi-Metals.

PROCESS CCVIII.

Antimony dissolved in aqua regia.

TAKE pure antimony, broke from the top of the cone, reduce it to fine powder, put a pound thereof into a low capacious glass-vessel, with a wide mouth; set the vessel under a chimney, that carries up fumes well, and pour to it a pound and half of *aqua regia*. A violent effervescence arises, a great heat, thick red fumes, and a hissing, all which soon after cease. There now remains at the bottom a matter of a grey and yellowish colour, moist, thick, and pappy, which is to be dried over a gentle fire, by keeping it sometimes stirred with a stick.

The use.

This is the humid calcination of antimony, whereby the fossil, which before was neither emetic nor purgative, now acquires very violent virtues. The yellow matter dispersed amongst this calx is the true sulphur of antimony, which the acid not dissolving, it is separated from the other metallic part of the antimony, which dissolves in *aqua regia*; whence we have both a calcination, and separation in this process; which is subservient to the following operations.

PROCESS CCIX.

The true sulphur of antimony.

TAKE the calx of the preceding process, wash and shake it with water, pour off the thick into another vessel; put on fresh, and continue thus, till the yellow lighter matter dispersed in the water, is separated.

rated from the more ponderous metallic part, which is to be kept apart : the sulphureous part, which falls to the bottom, being freed from the whitish water floating above it, may be thrown away. Then dry the powder by a gentle fire, and it will be true sulphur. If somewhat larger pieces of antimony were put into *aqua regia*, and the solution thus performed, larger pieces of sulphur would be obtained ; because the *aqua regia* seeks out, and dissolves the larger metallic parts concealed in the sulphur, and so makes the masses of sulphur more visible.

The use,

Hence it appears how secretly sulphur may lye concealed between metallic shoots ; and how surprisingly *aqua regia* can find out metal thro' the body of sulphur ; and again, how unchanged the nature of sulphur may remain. This is the sulphur of antimony, which *Helmont* orders to be extracted, and which he says scarce differs from the common, except in being a little greener : in reality, the difference is small ; nor does, perhaps, the cinnabar made with it, deserve the trouble, in respect of any greater virtue. Certainly, a seventh repetition of its sublimation, which he prescribes, is not so easy to perform as to direct. The experiment, however, shews, even to the eye, that antimony consists of a metallic and sulphureous part.

PROCESS CCX.

Glass of antimony.

1. **P**UT two pounds of powdered antimony into a large unglazed earthen dish, with a flat bottom, set it over a fire in the air, so that the powder may fume, but not melt ; in which management the whole art consists. Keep the powder constantly stirring with an iron-rod ; there flies off a thick, white, fetid fume, pernicious to the lungs, and therefore to be avoided by the operator, standing with his back to the wind. Continue the calcination uniformly, till the matter ceases to fume ; then increase the fire a little ; and if the matter again begins to fume, continue stirring till it leaves off. Again increase the fire, till at length the dish begins to grow red, whilst the matter emits no more fume : the calx will be of a greyish colour ; but if the calcination be longer continued with a stronger fire, so as to ignite the matter, the calx will be yellow, and better purified from its volatile parts. If the fire should be strong at the first, so as to melt the antimony, and make it lumpy, the lumps are directly to be broke to powder, and the fire to be diminished. This is the calcination of antimony *per se*, and a thing of great use. 2. Put this calx into a crucible, and apply fire round it, first at some distance ; gradually approaching it nearer, and at length bringing it quite close, so that the crucible being exactly covered to prevent the coals and ashes from falling in, may be thus uniformly heated and ignited. Increase the fire, till the calx melts, keep it fused for half a quarter of an hour, then pour it out, upon a dry

and hot-marble: it will be a dusky, yellowish, brittle, somewhat transparent, and hard cake, called the glass of antimony; it will appear the more transparent, the longer it was boiled in the fire.

The use.

Sulphur consists of common brimstone and a metallic matter, as we saw in the two hundred and ninth process; but sulphur is totally volatile in the calcining fire here applied, as appears by the hundred and fiftieth process: the metallic part sustains a fire of fusion, as appears by its being melted, and poured into cones; but then it always yields a white suffocating fume. Hence we understand, that powdered antimony, being roasted in a fire that does not melt it, this gradually drives out the external sulphur, thence purifies the metallic glebe, and at length reduces it to a calx, which, tho' the antimony was innocent before, now proves violently emetic: whence this should happen is not hitherto well understood. This calx, when melted, is the glass of antimony, made after the manner that we saw of lead. Antimony and lead are by the adepts said to agree in many respects; and it appears in this, that the calces of both turn into glass by fusion. The glass of antimony is almost mortally emetic; and when infused in wine, that is not considerably acid, it renders the liquor vomitive, without any great loss of its substance; tho' this virtue is soon exhausted, by often repeating the infusion: and hence proceed the common emetic wines. This glass, in fusion, consumes almost all metallic bodies, upon the test, except gold, to which it gives a beautiful and rich colour.

PROCESS. CCXI.

The regulus of antimony with salts.

1. **T**HIS effect is obtained by any method of separating the metallic from the sulphureous part of the antimony; and the more exact the separation is made, the purer the regulus will be. Fossil antimony, in its native glebe, being put into conical earthen-pots, with the narrow end downwards, is melted with a gentle fire, sufficient to make them reddish, into large cones; whilst the purer, more ponderous, and metallic part remains below, in the *apex* of the cone, and the upper wide part is more spongy, dusky, and sulphureous: and thus a regulus is made by bare fusion.

2. Take two parts of common nitre, three of good tartar, and four of pure antimony; let them be dry, and grind them separate to fine powder; then rub them together perfectly dry, till they are thoroughly mixed. Let the mass be made moderately hot, but chiefly very dry; then set a large crucible carefully in the fire, so as to be on all sides surrounded with the coals, and perfectly ignited: throw into it two drachms of the mixed powder made hot, and very dry; there will arise a violent deflagration, with a considerable noise, and sparks flying every way about. After the detonation is over, throw in the like quantity; and continue thus till all that was intended, and answering to the size of the crucible, be

thrown in. The cautions required in the operation are these. Let the crucible be large, lest the matter in boiling up violently should run over: throw in but little powder at a time, lest it should leap out of the vessel in large sparks. Let each part thrown in be perfectly fired, brought to rest, and thoroughly ignited before another is added; lest the matter, being hotter below, and colder above, should form a crust at top, so as to confine the fire, and occasion a sudden loud explosion, which might be much more violent than that of a musket: for gunpowder is thus formed of the nitre, tartar, and sulphur. Let the crucible be kept constantly hot, to prevent the same explosion and danger. A person unacquainted with these particulars, and endeavouring to make regulus of *antimony*, in the method directed, may endanger his life; but if these cautions be carefully observed, the whole may be safely done. And after the matter is all detonated, increase the fire, cover the crucible with a tile, and make the matter flow like water; have ready at hand a metallic melting cone, perfectly dry, a little heated and greased on the inside with tallow-candle, into which at once pour all the melted matter, and immediately shake the cone; there instantly arises a flame from the firing of the tallow. Let all rest and grow cool, invert the cone, and give a stroke on the basis with a hammer, thus the regulus will fall out; the lower part whereof is the metallic matter of the antimony, the upper consisting of the salts and sulphur: the upper metallic surface where it touched the *scoria* has the figure of a star impressed upon it: the *scoria* swells, and re-lents in the air.

The use.

As this process lays a solid foundation for the business of metallurgy, it deserves to be carefully considered. In the first case, therefore, the fossil mass of antimony, being melted, with a proper fire, becomes fluid and ponderous: whence the lighter adhering matters, such as stones, and other bodies, not cleaving to the metallic part in fusion, are by the law of hydrostatics, thrown to the top, and separated, so as to render the metallic part more pure and ponderous. And thus, in metallurgy, the metallic matter is often separated from the rest by fusion. But in the second case, the metallic matter is by another metallurgical art separated from the sulphur, which would not separate by simple fusion, but remained intimately mixed with the former; and this was done by means of the powder of nitre and tartar, and is therefore called the flux-powder. For, as antimony consists of sulphur and metal, according to the two hundred and eighth, and two hundred and ninth processes; being here mixed with nitre and tartar, and committed to the fire, the nitre and the tartar, together with the sulphur of the antimony, immediately take fire with great violence, according to the hundred and thirtieth, and hundred and thirty-second processes; whereby a fixed alkali is made of the nitre and tartar, as in the hundred and thirtieth process. But this fixed alkali, being agitated by the violence of the fire, greedily drinks in and unites sulphur to itself, according to the hundred fifty-second process; whilst the metallic, or mercurial part remaining untouched by the alkali,

alkali, freed from its sulphur, fused by the fire, and fallen downwards from the lighter matter, unites at the bottom into a regulus. And as the long pointed *spicule* of the antimony, when left separate, range themselves horizontally upon the surface, from the centre to the circumference, they thus form a star, which the alchemical *Magi* adore. This regulus, tho' it appears pure, being again fused with alkali, affords a new sulphureous *scoria*, and perhaps will never become perfectly free from sulphur; whence it is always brittle: for sulphur always destroys the ductility of metals. The *scoria* is the sulphur of metals dissolved in fixed alkali, as in the hundred and fifty-second process, whence its virtues are easily understood. This regulus of antimony is emetic, like the glass of the preceding process; and in the same manner renders wine vomitive, by being infused therein. And hence we have another way of purifying metals by salts, from all their sulphureous and arsenical matters, which renders metallic glebes fragile and volatile, and which, when separated, leaves the metal pure and fixed.

PROCESS CCXII.

Regulus of antimony with iron and nitre.

TAKE half a pound of bright iron-filings, heat them in a crucible, gradually put thereto a pound of finely pulverized antimony, first well dried and heated; keep it in a strong fire, so that it may flow thin; by degrees throw in four ounces of pure, dry, and hot pulverized nitre; make the fire violent, that the mass may run like water; keep it thus for half a quarter of an hour; then pour it out into a melting-cone, as in the preceding process. There will thus be obtained seven ounces and a half of stellated regulus, as bright as silver. The *scoria* here is of a very different nature from that of the last process, being dry, hard, irony, sulphureous, saline, sharp, and will scarce relent in the air.

The use.

The sulphur of melted antimony easily joins itself with ignited iron, according to the hundred and seventieth process; and hence proceeds a sulphureous *scoria* of iron: and upon the addition of nitre there arises a strong deflagration with some part of the same sulphur, according to the hundred thirty-second and hundred thirty-third processes. And the fusion, being here perfect, the metallic part of the antimony falls alone to the bottom, by its own gravity; whilst the sulphur of the antimony, along with the iron and nitre, are separated and float at the top. *Paracelsus* observed, that iron separated the sulphur of antimony much more intimately, from its mercurial part, than vegetable alkali could; and therefore, that this operation was much fitter for separating the mercurial part of antimony for secret chemical uses. The experiment certainly shews that sulphur may be excellently extracted from ores by means of iron, and hence their metals rendered fixed, and malleable;

able; whence *Alexander Van Suchten*, a disciple of *Paracelsus*, wrote two treatises in this view upon antimony; from whence we have the following process.

PROCESS CCXIII.

The alchemical regulus of antimony.

1. **P**UT half a pound of iron nails into a strong and large crucible; set it in a wind-furnace; raise the fire till the nails are perfectly ignited, whilst the crucible remains covered: then add, at several times, a pound of dry and thoroughly heated antimony, reduced to powder; cover the crucible a while: as soon as the antimony is put in, it yields a white fume, and soon after runs, and thus also presently melts the iron: when they flow thin, which is known by trying with a long tobacco-pipe, throw in, at several times, three ounces of very dry and hot powdered nitre. After each injection there arises a strong ebullition, a tumult, noise, and sometimes a crackling, or decrepitation. And if the nitre were thrown in moist, the vessel would burst, and the matter fly about in a very dangerous manner. When it has continued thus for some time, shining sparks are thrown out. Let the whole flow like water for five or six minutes, then pour it out, whilst very thin, into a melting-cone, which being directly struck on the outside, and suffered to cool, the regulus will easily fall out. I have thus had eleven ounces and six drachms of it, and eleven ounces of scoria; so that the loss was four ounces and two drachms, besides what remained in the crucible upon pouring out.

2. Melt this regulus again in a new crucible, and throw into it three ounces of dry and hot powdered antimony. When melted, throw to them, at several times, three ounces of dry and hot powdered nitre; fuse them with a strong fire, and keep them five minutes in a thin fluid state: then pour out the matter into a melting-cone, and it will afford ten ounces and six drachms of a pure regulus.

3. Melt this second regulus in a new crucible, and after the same manner throw to it three ounces of nitre; use a very violent fire, otherwise it will not run; pour it into the cone, and thus nine ounces and two drachms of a regulus will be obtained, white like silver, and beautifully starred: there remains two ounces and seven drachms of scoria, so that the loss is an ounce and five drachms.

4. Melt this regulus also in a new crucible, and throw in three ounces of nitre; the nitre now requires a violent fire to make it run, tho' the regulus flows like water below it; keep them in liquid fusion for an hour, then pour them into a melting-cone; thus there will be obtained seven ounces and three drachms of an extremely pure regulus, like silver, and beautifully starred: there remain two ounces and seven drachms of scoria of a gold-colour, and very fiery taste. This is a surprizing experiment.

5. The crucibles here ought to be strong, sound, large, and properly heated by degrees: the fire must be strong and equable, otherwise the nitre will not melt, nor the operation succeed; the melting-cones must be moderately hot,

- ' hot, perfectly dry, every way pure, and greased with tallow-candle; and
- ' if these cautions be observed the operation will succeed.

The use.

This process shews us many useful particulars: for example, iron, which is so hard of fusion, melts in antimony, as all other metals do in lead: the iron, corroded by the melted antimony, unites with the sulphur thereof; the mercurial part of the iron and the antimony are set free, unite together, and fall to the bottom: the sulphur of the antimony and the iron unite, and rise to the top. Nitre being thrown in, burns violently with these sulphurs; intimately agitates the minutest part of the whole, and all the principles, uniting the similar, and separating the dissimilar parts. Iron is destroyed by the force of antimony, whilst the metallic sulphur of the iron, that is the gold of the alchemists, intimately unites with the metallic sulphur of the antimony; and they both remain with the mercurial part of the antimony in the form of a stellated regulus, which shining like silver, shews the purity of its mercury. The scoria contains the iron, the sulphur of the antimony, and the nitre united together, into a wonderful body; the secret medicinal virtues whereof will be recommended by such as know how to treat and apply it properly (a). It strangely swells in the air: and so much of the first fusion. In the second, the external sulphur is farther drawn out; the metallic sulphurs of the iron and antimony, together with their mercuries, are more fixed into a purer regulus; the sulphureous scoria floating upon the nitre. In the third fusion, a wonderful power of the sulphureous metallic fire, concealed in this regulus, begins to shew itself, and by fixing the nitre, renders it extremely difficult to fuse; whereas it was before of all natural salts the readiest to melt in a gentle heat; and giving it a most intolerable fiery taste, so as to burn the tongue; whereas the proper taste of nitre is very cold. It turns the nitre alkaline without the assistance of any vegetable, and makes it spontaneously melt in the air, in which it remained dry before. The fourth fusion shews the same more manifestly; where the nitre is thus more powerfully changed by the bare touch, or as it were the breath of the pure sulphur; which shews the secret power of metallic sulphurs. This regulus has surprized the most experienced chemists. See *Paracelsus, Suchten, Philaletha, Pantaleon, Becher, and Stahl*. The colour of gold is as much exalted by means of this regulus, and restored when lost, as the whitest nitre, when thrown upon this regulus in fusion, immediately thence acquires a golden colour. When I recollect the labour and time I have bestowed upon examining the nature of this regulus, I am surprized at my own patience and resolution; and blush to have spent so large a part of my life upon it: but every man has his pleasure. The regulus, tho' thus purified, is still emetic; and the scoria gives a rich tincture to alcohol.

(a) The author intimates below that it gives a rich tincture to alcohol.

PROCESS CCXIV.

The golden sulphur of antimony.

BOIL the scoria of the two hundred and twelfth process in water, till it is all dissolved; the solution will be scentless: drop vinegar into it, and there instantly rises a very fetid stercoraceous odour; and the liquor that before was thin becomes very thick. Continue to add more vinegar, and stir the matter, till nothing farther precipitates. Let the matter rest; the precipitate will gradually fall, and come into a much smaller compass than one would expect: pour off the liquor, wash the precipitate in several waters, till it becomes perfectly insipid; dry it gently; there will be but little of it; and this is the golden sulphur of antimony.

The use.

The sulphur of antimony, mixed with alkali, makes the scoria of the two hundred and twelfth process; which scoria being boiled in water, affords a sulphureous lixivium, that with acids precipitates the sulphur. It has a mild emetic virtue; and is called golden sulphur, because, when rubbed upon silver, it gives a gold colour thereto.

PROCESS CCXV.

The crocus of antimony.

REDUCE equal parts of antimony and nitre to fine powder; heat an iron-ladle over the fire, almost red-hot; throw a little of this powder therein; it takes flame like gunpowder; when the flash is over throw in more, which takes fire as before. Continue thus till all the powder is thrown in; it will be of a brown yellowish colour; a kind of glass remaining at the bottom, and a lighter scoria at the top. Grind the whole to fine powder, and wash it with hot water, till the brownish-yellow calx remains insipid; which when dried, it is the *crocus* of antimony. Filter the waters to render them transparent; drop a little vinegar into them; they turn of an orange colour, and let fall to the bottom a powder extremely like that of the preceding process, but finer.

The use.

Sulphur and nitre make a kind of gunpowder with black antimony, and therefore flash off in the same manner. The metallic part calcines to a glass and a scoria, both of them violently emetic, and communicating that virtue to wine by infusion; whereas native antimony is not vomitive. Here is a remarkable change of colour. If the operation be performed in a large crucible, with a strong fire, and a great quantity of matter, which is made to melt, there will be an extemporaneous glass found at the bottom; and which being

The Practice of CHEMISTRY

329

being separated from the scoria, is the same for medicinal uses, as that more laboriously prepared in the two hundred and tenth process.

PROCESS CCXVI.

A mild emetic from antimony.

GRIND one part of antimony with two of nitre; throw them by a little at a time into an ignited crucible; they will detonate as in the last process; but the matter will prove white, and being washed, affords a white insipid calx of antimony: the water used in the washing is saline, when filtered.

The use.

The proportion of nitre being here increased, gives a different colour, but the same deflagration. This calx is so mild, as often to occasion only some light nausea and gentle vomiting, with a large discharge of saliva and thick urine, from stimulating the viscera. Its lixivium being precipitated with vinegar, affords a white calx of nearly the same virtue.

PROCESS CCXVII.

A diaphoretic antimony with nitre.

TAKE one part of antimony, and three of nitre reduced to fine powder; throw them by a little at a time into an ignited crucible detained in the fire; they will deflagrate as above. Continue thus till all the powder is put in; with care not to add fresh till the former is perfectly deflagrated. Keep the matter for a quarter of an hour in the fire, that the crucible may remain ignited: let all cool; there will remain a white and hard mass, which being taken out, and reduced to powder, is the diaphoretic antimony with nitre.

The use.

This matter, thus rightly prepared, being taken in the quantity of half a drachm, scarce occasions any sensible change, excepting that it moderately opens on account of the fixing nitre adhering thereto; whence it may prove serviceable in acute cases. In this state the chemists call it diaphoretic, and judge, that the arsenical poison of the antimony is fixed by a large proportion of nitre; but there was nothing emetic in the antimony before, tho' taken in the quantity of several drachms crude, or without any nitre; whereas an equal proportion of nitre excites this vomitive virtue. Let us not reason too far, but rest safe in the experiment. Basil Valentine therefore, and other chemists, needed not have been so anxious to free this diaphoretic antimony from its fixing nitre; for it causes no anxiety, nausea, or vomiting, and only stimulates mildly: but the washed calx proves more mischievous.

The Practice of Chemistry

PROCESS CCXVII.

Common diaphoretic antimony.

REDUCE the calcined antimony of the preceding process to fine powder; wash it with hot water; mix it with a stick; whereby the adhering, fixing nitre will be dissolved, and a white calx subside by standing. Pour off the saline liquor, add fresh water, and edulcorate the calx, so that no sensible taste of the nitrous salt may remain; then dry the powder, and it will be white, insipid, and ponderous, or the common *antimonium diaphoreticum*.

The use.

This preparation is called diaphoretic, for the reason mentioned in the last process. It is an indolent, noxious calx, without any activity discoverable by observation; and loses all the virtue it had before. It only acts sensibly; when mixed in a double proportion with purgatives, the virtues, whereof it actually excites, as appears by sure examples in the *pulvis cornacchini*; but I recommend it for no other use. Hence we see how wonderfully the colours and virtues of antimony are changed, by barely changing the proportion of the nitre in its calcination.

PROCESS CCXIX.

Nitrum antimoniatum.

PUT the filtered waters of the preceding process into a glass-urinal; evaporate to dryness, and keep continually stirring; at last there remains a white saline matter, of a particular taste, not ungrateful, nor nitrous, but mild; and this is called *nitre of antimony*.

The use.

Hence we see the nitre is changed into a new salt, by detonating with antimony. This salt is gently aperitive, and, in dense inflammatory blood, excellently resolves without violence: it successfully promotes perspiration, sweat, and urine; hence cools and becomes serviceable in the small-pox, measles, pleurisy, and peripneumony: it is therefore wrong to throw this water away as noxious; which is commonly done.

PROCESS CCXX.

The fixed sulphur of antimony.

TO the filter'd nitrous liquor of the preceding process, whilst it remains hot, and contained in an urinal, drop strong distilled vinegar; the liquor will presently turn milky, and a very white and fine powder precipitate.

pitae. Shake the glass, continue to drop in vinegar, and stir the liquor till it appears no longer turbid; then let it rest till all the powder is fallen: afterwards pouring it off into another vessel, perfectly edulcorate the powder with water, dry it, and it will be exceedingly white and fine: this is called the fixed sulphur of antimony.

The use.

In the deflagration of antimony with nitre, the sulphur of the antimony unites with the nitre; as appears by the two hundred and fifteenth process: and the same is the case here; but the sulphur, so dissolved and joined with the nitre, also dissolves with it in water, and, by the addition of an acid, is precipitated out of the nitre, as here by the means of vinegar, which joins with the nitre, without any sign of effervescence: the powder precipitated and washed is the true sulphur of antimony. *Tachenius* commends this powder as an excellent antipestilential remedy, if taken with vinegar. In my opinion the powder is to be esteemed a sluggish calx, insoluble, and hurtful by its weight; at best not serviceable: the vinegar, however, given with it, I own, is an excellent remedy in the plague: but it is usual with Chemists rashly to commend whatever their art prepares, especially from antimony; and the more, if it does not operate violently. The acetous, nitrous liquor, that floats above the precipitate, has extraordinary virtues in all acute, feverish disorders, as well on account of the vinegar, as of the mild nitre, now set free from its former sluggish sulphur: and thus the best things are often thrown away in chemistry. In these several processes we see how wonderfully sulphur may be dissolved, lie concealed, and be raised again in various forms and colours.

PROCESS CCXXI.

The distillation of antimony into an icy butter, and cinnabar.

GRIND two pounds of corrosive mercury-sublimate to fine powder; in a warm and dry glass mortar, with a glass pestle; grind also separately a pound of the best antimony perfectly fine; mix the two together in the glass mortar; they will thus grow warm; and let the vapour be carefully avoided: have at hand a dry glass retort, capable of holding three or four times this quantity of matter, with its neck cut off, so as to leave a wide mouth. Put the powder, whilst thorough dry, into this heated and dry retort, so that no blackness may stick internally to the short neck; put the retort into a sand-furnace fit for the purpose, so as almost to touch the bottom of the iron pot, the neck of the retort inclining a little downwards; apply a glass receiver, with the neck cut off, so as exactly to receive the retort. Cover the retort with sand, and let the operation be performed under a chimney that entirely carries up the fumes: The retort being now warmed by a very gentle fire, and luted on with a mixture of lime and clay, raise the fire cautiously, by degrees; the retort will first appear cloudy, and a little liquor come into the receiver; keep up this degree till no more

The Practice of CHEMISTRY.

liquor comes over; then increase the fire gradually and carefully, till an unctuous matter rises into the neck of the retort, distils into the receiver, and coagulates in falling. Continue this degree of fire, and a white icy matter will concrete, and remain in the neck of the retort; on both sides of which place live coals at a distance, and approach them nearer by degrees, that the neck of the retort may become as hot as the belly; the matter will thus be melted, and run down into the receiver. Continue carefully with this degree of fire, and afterwards a little increase it, till no more butter rises, and all of it be melted down into the receiver, which is now to be removed with great care, to prevent any of the vapour coming to the lungs. Immediately stop the receiver, and set it by; apply another, fitted in the same manner for the purpose; lute it on, increase the fire, and a yellow, red, blackish, variously coloured mass will arise; then increase the fire to the utmost, at last raising a fire of suppression, till the sand almost grows hot; and leave it thus for two hours. Let all cool; take off the receiver, wherein some quantity of running mercury will be found, and an impure butter, from the sulphureous fumes of the sulphur of the antimony. In the neck of the retort will also appear a matter of various colours, consisting of the mercury, sulphur, and butter, compounded together; and at the bottom of the retort, when broke, appear antimonial faces: in the beginning of the neck is a compact, hard, opaque, highly ponderous mass, which shines on the surface contiguous to the glass, but is rough on the other: this being ground to powder is the true cinnabar of antimony, and a thing of value. Great patience and care are required in this process; because if the vessels or luting crack, or the fumes any other way escape, and are received into the lungs, they are poisonous, on account of their caustic property.

The use.

From a knowledge of the nature of antimony, and mercury-sublimate gained by the preceding processes, we may easily understand the chemical rationale of the present operation. Whilst the fire acts upon the mercury-sublimate, the *aqua regia* contained therein unites with the mercurial, metallic, reguline part of the antimony, forsaking the mercury whereto it was first joined, and leaving it to run at the bottom, whilst the regulus is sublimed along with the salt, and becomes the volatile vitriol, or butter of the antimony, consisting of pure regulus of antimony, and sea-salt, united into a vitriol. When these are separated and sublimed, there remains in the retort a sulphur of antimony deserted by the regulus, and a pure mercury deserted by the acid; whence these two, uniting with the heat, sublime into cinnabar. This butter of antimony is a most immediate caustic, causing an eschar the quickest of any thing known, and which generally separates the same day it was formed. This butter easily melts in a moist air, then loses its transparency, turns white, and precipitates a white powder. The various colours in this process arise from the sulphur of the antimony. The butter here produced melts with heat, and again freezes with cold. If instead of antimony, the pure regulus of antimony, made according to the two hundred and thirteenth process, be used, and the

the operation be performed in the same manner, a pure butter only, and a pure mercury will be obtained, because there is now no sulphur; and all the acid being drank into the regulus, the mercury is recovered separate and pure. Here we see an extraordinary property of spirit of salt, which adhering to the mercury-sublimate, is able with a sand-heat to sublime the fixed regulus of antimony. It likewise does the same to all metallic bodies, even gold itself. Sea-salt is a wonderful body, upon which the chemist can never sufficiently operate, and will always be rewarded for the pains he shall bestow upon it.

PROCESS CCXXII.

Butter of antimony distilled into a liquid oil.

BREAK butter of antimony to pieces by means of some glass instrument; put it into a clean glass retort, with care to avoid its melting by the air, lest the vapour should offend the operator; distil it with a gentle fire, gradually increased, into a pure dry glass receiver; continue increasing the fire till all the butter is come over, using a strong one at last; it will be almost liquid, in form of the oil of antimony; and, if distilled thrice over, it becomes clearer, and, when well kept in a close vessel, remains in this state.

The use.

This is a very extraordinary event, and may serve to illustrate some obscure passages of *Paracelsus*. This excellent experiment discovers many particulars concerning the volatilizing of metals, and converting them into a true kind of liquid oil; the inscrutable power of sea-salt for procuring of volatility to metals; and its wonderful property whilst remaining united with antimony, as being then highly poisonous, and yielding true arsenical fumes, yet when separated from the antimony again becoming perfectly innocent. Hence we may suspect something of the properties of the alcahest. It renders all metals distillable by the retort, without altering their gravities; and again restores them almost without any alteration of their properties: this matter deserves to be farther inquired into. The oil here affords a highly expeditious caustic in chirurgery, when carefully used. This process is esteemed a great secret. Whilst performed, let the fumes be carefully avoided: I knew them once prove mortal to a very excellent and eminent person; therefore again, let them be carefully avoided.

PROCESS CCXXIII.

The mercurius vitæ of antimony, and its regulus.

INTO a glass of fair water let fall a drop of the rectified oil of antimony of the preceding process; the moment it falls it becomes white, turns to powder, and sinks to the bottom of the vessel. Continue to drop in more,

more, till a fourth part of the oil be used in respect to the water; it instantly sinks to the bottom, in form of an exceeding white ponderous powder. Stir all with a glass rod, let them rest, a limpid acid liquor will float above, which is gently to be decanted; perfectly edulcorate the powder, by washing it in several fresh waters, till it is entirely insipid; dry it with a gentle fire, and thus there will be obtained a white, insipid, ponderous powder, called *mercurius vite*.

The use.

Hence we see the acid of sea-salt adheres to the regulus of antimony only whilst it remains very strong, but presently quits it, and is attracted into the water, when diluted with a large proportion thereof. This powder, being given in the quantity of two or three grains, is violently emetic; whence some, on account of its tragical effects, have called it *mercurius mortis*. If it be for a long time exposed upon glass to a gentle fire, and kept constantly stirred, it loses of its violence, becomes less active, and is by many said to be the secret of *Riverius*. This powder contains not the least mercury, but is a pure regulus of antimony. I took eleven ounces of *mercurius vite*, which I had prepared my self, and put it into a strong large crucible in a blast-heat; the powder melted, as soon as the crucible was thoroughly ignited; then pouring it into a melting-cone whilst it run thin, I had ten ounces of regulus, consisting of wonderful dense shining needles, but somewhat greyish.

PROCESS CCXXIV.

The philosophical spirit of vitriol.

FILTER the limpid acid liquor of the preceding process, inspissate it to a half, and the philosophical spirit of vitriol is obtained.

The use.

This limpid liquor is gratefully acid, has the taste of spirit of sea-salt, and, like that, may be employed perfectly with the same effect, both in chemistry and medicine. It is no way emetic, but a pure spirit of sea-salt, that still retains its nature thro' so many operations with mercury-sublimate, the butter and oil of antimony, and water, even without being fouled therewith, but still remaining a wholesome acid. It is improperly called spirit of vitriol, as containing nothing thereof; for with the alkali of tartar it regenerates sea-salt again. I cannot but admire, and be pleased with sea-salt in chemistry; and being desirous to know the nature of this production, I distilled a large quantity thereof in a tall glass body, and found nothing left at the bottom, the liquor coming over extremely pure. Therefore the water thus instantly drew out the spirit from the butter of antimony, by being barely poured thereon, so as to leave not the least antimony in the spirit, which being before mixed with the regulus, rose in the form of butter by the retort. I again distilled all this liquor in a tall glass body, and the third time with the gentle heat of about a hundred degrees; when there arose a pure water, without any

any manifest acidity to the taste; and continued with this degree of heat, till nothing more would come over. I urged the remainder with a somewhat stronger fire, till a tartish liquor ascended. I kept apart all that could be thus raised, under the title of the acid phlegm of the philosophical spirit of vitriol, which is of good service where gentle acids are required. I distilled the remaining liquor in a glass-body, and found it a highly acid, somewhat smoking, but exceeding limpid and fat spirit of sea-salt: and thus I learnt the wonderful nature of this salt, how easily it would unite, and how easily separate.

PROCESS CCXXV.

Helmont's flowers of antimony.

TAKE a pound of antimony, dissolved in *aqua regia* according to the two hundred and eighth process; put it into a low glass with a wide mouth; set it for a considerable time over a gentle fire; stir it constantly with a glass rod, till the matter becomes entirely dry; grind it in a glass mortar with a glass pestle to fine powder; add an equal weight of dry sal-ammoniac in proportion to the calx of the antimony; grind them together, the longer the better, that they may be thoroughly mixed; put the matter into a low glass-body with a wide mouth; clap on a capacious and clean alembic-head; lute the juncture with a mixture of linseed-meal and water; set the body in a sand-furnace with its pipe a little slooping, that the water which rises in the sublimation may easily fall into the receiver applied; raise the sand up to the rim of the alembic; then make a gentle fire, and increase it by degrees. There first comes over a limpid acid water, which is all made to rise by increasing the fire a little; the fire being raised again, a whitish matter begins to appear, at which time the fire is to be kept so strong, that the hand can scarce endure the heat of the glass-head, in which almost all the known kinds of colours will appear. This fire being continued eight hours affords a beautiful sight, as if the head was painted of various colours. Let all cool gently; take out the body, and wipe both that and the head clean from any external dust or foulness; take off the head, but beware of the first fume. Nearly the whole antimony will appear raised with the sal-ammoniac into a variegated matter; take it out quick, and put it into a hot dry glass, under the title of *Helmont's saline flowers of antimony*. They are violently emetic, even in the smallest dose. There remains something at the bottom, which may be sublimed with more sal-ammoniac. 2. Put these flowers into water, the water will turn milky; mix them well together, then let them rest; a saline ammoniacal liquor will float above, which is to be decanted; wash the flowers till they become perfectly insipid; dry them by a gentle fire, and there will be obtained a subtile, red, highly emetic and insipid powder, called *Helmont's dulcified emetic flowers of antimony*. The several waters being inspissated restore the sal-ammoniac, fit for the same use.

The use.

Here we have an example of the method wherein *Paracelsus* imagined, that a chemical death and resurrection opened the bodies of metals, for exerting their power upon the human body. Thus what is fixed becomes volatile, and all kinds of pigments are made. Here the black powder of the antimony is the crow's head, the white calx thereof the swan's neck, and all the beautiful colours taken together are the peacock's tail; and every one of them is emetic.

PROCESS CCXXVI.

Helmont's fixed diaphoretic flowers of antimony.

TAKE one part of the dulcified flowers of the preceding process, and three parts of pure dry nitre; grind them thoroughly for some time in a glass-mortar; throw a little of this heated mixture into a clean crucible, kept ignited in the fire; it will thus flame, though weakly. After the flash ceases throw in more; and thus continue till all the matter is deflagrated. Let all cool; a white yellowish substance will be found in the crucible; take it out carefully, grind it, wash it with water, dry it, it will thus become a fine white powder; put it into a china vessel, burn alcohol upon it, and keep stirring the powder with a tobacco-pipe, so long as the alcohol flames; and this ceasing, the powder is *Helmont's* diaphoretic; thirty-six grains whereof are said to cure all intermitting and continued fevers by sweat.

The use.

Here again we have an example of fixing a volatile matter for chemical uses. This diaphoretic is highly exalted by its author. I have often made and used it, but could never find it had such excellent virtues as he relates of it in his *Aurora Medicinæ*, written in *Dutch*; whence I believe he was also somewhat too profuse in praising his other remedies.

PROCESS CCXXVII.

Helmont's purging diacelatesson, from the fixed flowers of antimony.

1. TAKE eighteen grains of the fixed diaphoretic antimony of the preceding process, sixteen grains of the rosin of scammony, and seven grains of cream of tartar; make them into a fine powder. 2. Or take nine grains of fixed diaphoretic antimony, nine grains of rosin of scammony, and three grains of cream of tartar; make them into a fine powder. This is the description of *Helmont's* purging powder, called *diacelatesson* by *Paracelsus*. The former is the largest dose for a grown person, and the latter the least. They are to be taken without any acid: if they operate too violently, the operation may be stopped by taking any acid. This powder

‘ powder being given in intermittents, so as to finish its operation immediately before the fit, is said by its author constantly to cure quartans, before the fourth dose, and all intermittent and continued fevers (a).

The use.

We have here another example of a chemical secret, of which *Helmont* says that it radically cures the gout and fevers; that it heals ulcers of the *larynx*, *oesophagus*, and bladder; that it purges the body, when imperfectly healthy, and not otherwise. He adds, in the *Latin* edition (b), that the dose is eight grains; whence it appears, that the *Dutch* account is different from the *Latin*. I always suspect that this great man carried the power of his secrets, by the subtlety of reasoning, beyond what is warranted by experience. I have often prepared these powders with my own hand, and given them; but never could observe any superlative, tho’ always good effects.

And here I finish the set of processes proposed. I have kept to the design of exhibiting those which were sufficient for understanding the rest: I will now add an Appendix concerning certain operations in Physics and Medicine; and these operations may be understood from the preceding processes, by a short recapitulation.

A P P E N D I X.

Chemical Solution.

1. **SOLUTION** is performed with water; by diluting, infusing, boiling, distilling, mixing, fermenting, putrefying, and separating.
2. With oil; by diluting, infusing, boiling, distilling, mixing, separating; but not by fermenting, or putrefying.
3. With fire; by calcining, roasting, burning, melting, subliming, mixing, separating, and promoting other operations.
4. With the assistance of the air; by fermenting, putrefying, agitating, exciting, and adding other parts capable of dissolving.
5. With fermented spirits; by diluting, infusing, boiling, distilling, mixing, and making oils thinner.
6. With alkaline salts; by calcining, torrefying, burning, melting, mixing, and separating, according to the various force of a dry fire employed.
7. With volatile alkaline salts; by subliming in the dry way; and by diluting, digesting, and distilling in the moist one.
8. With fixed alkaline salts, assisted and moved by water and fire; by digesting, boiling, diluting, separating, and mixing.
9. With fixed acid salts; as those of alum, sulphur, and vitriol, either separately in a liquid form, or in their calxes, by diluting, boiling, distilling, digesting; or in a dry form, by calcining, roasting, burning, or distilling.

(a) See *Helm. Aurora Medicin. Belgicæ* edit. pag. 187, 188, 288.

(b) Pag. 775, 776.

The Practice of CHEMISTRY.

10. With volatile acid salts; by diluting, digesting, distilling, and insinuating.
11. With compound salts and soaps; by calcining, subliming, distilling, and digesting, either in a dry or liquid form.
12. With metals, by fusion and amalgamation.

Chemical Coagulation.

1. **C**OAGULATION is performed with water; by congealing, crystallizing, and precipitating, as in the *mercurius vite*.
2. With oil, which by the force of fire unites to itself sulphur, salts, and metals.
3. With alcohol; upon the volatile spirit of sal-ammoniac, the white of eggs, the serum of the blood, and oil of vitriol.
4. With alkali and acid, growing solid together; as particularly in the tartar of vitriol.
5. With fixed alkali; as in milk.
6. With acid salts; as in milk, serum, and white of eggs.

Chemical Precipitation.

THIS action is a manifest separation of a body dissolved, and made to depart from its solvent upon the mixture of some new thing. The operation is of great use, and deserves to be carefully considered, and has been frequently observed in the processes.

1. It is performed by water poured to oils dissolved in alcohol, where the liquor turns milky.
2. With water poured to solid resinous bodies in alcohol, where also the liquor turns milky.
3. With water in the distillation of oily spirits, if at the end any water run after the spirit is drawn off.
4. With acids by acids; thus silver and mercury are precipitated out of spirit of nitre by spirit of salt.
5. With metals by metals and other bodies. Thus, for example, dilute an ounce of silver, dissolved in spirit of nitre, with twelve times the quantity of rain-water; put polished plates of copper into the liquor, the silver will be presently precipitated, and the copper dissolved. Put this solution of copper into another glass, and add to it polished plates of iron; the copper will presently be precipitated, and the iron appears cased over with copper; the copper falls to the bottom, and the iron dissolves. Pour the solution of iron into a fresh glass, and drop into it oil of tartar *per deliquium*; the dissolved iron immediately falls to the bottom, the alkali unites with the acid, and regenerates true nitre, after so many changes. And thus the soul travels from one body into another almost unaltered; tho' it is more attracted by one than by another, till at length it rests in that which in this respect is the strongest, and is only thence expelled, as when oil of vitriol is poured upon nitre thus regenerated. And upon these two principles precipitation depends,

pend, which is the true, and often abstruse cause of numberless operations, both in art and nature. Take a grain of white or red mercury-precipitate, rub it upon the surface of a polished and heated copper-plate, which will thus immediately shine like silver; for the copper attracts the acid of the nitre from the calx of mercury, and thus presently makes an amalgam upon the surface of the copper, and then acquires a silver colour.

6. Alkalies often precipitate things dissolved by acids. This happens frequently, but not always, nor in perfection. Alkali precipitates copper dissolved by an acid; but the copper is afterwards dissolved by a salt made of the two.

7. Acids generally precipitate things dissolved by alkalies; but in this case also there are some exceptions.

8. Sharp salts without being changed, and lying perfectly concealed, have strange and unexpected effects, by means of precipitation. If an ounce of *luna cornea*, which is perfectly scentless, insipid, and inactive, and affords no sign of acrimony in the fire, be ground or united, by a strong heat, in a glass-retort, with half an ounce of inodorous and perfectly insipid regulus of antimony, there instantly arises an exceeding strong poison, or an extremely corrosive butter of antimony, the exhalation whereof proves mortal. Whence we see how dangerous the art of mixing is, and what caution should be used in the compounding of bodies.

Chemical Effervescence.

1. **A** SUDDEN agitation arising upon the bare mixture of two bodies, which lay at rest asunder, is called effervescence. This arises various ways; we shall here mention a few, which may serve to illustrate the rest.

2. The principal bodies in which effervescence happens, are, (1.) Native vegetable acids, as most juices of trees, shrubs, and plants that run in the spring; most juices of unripe summer-fruits; particular juices remaining acid when ripe, as of oranges, citrons, lemons, tamarinds, sorrel, wood-sorrel, and crabs; fermented acid vegetables, the meals when they turn sour, *Rhenish* and *Moselle* wine and tartar; vegetables twice fermented, native and distilled vinegars; the acids of animals from tartish or acid vegetable aliment, as in the chyle, sour milk, whey, butter-milk, and the whey thereof; the native acids of fossils, as the acid of sulphur, alum, or vitriol; or these acids as they lie concealed in sulphur or vitriol-stones, or as thence extracted by a violent fire, or a stronger acid, as in the spirit of nitre, salt, alum, vitriol, and sulphur.

3. True fixed alkalies made of any vegetable matter by burning; the more volatile alkalies, whether spontaneous, as in garlic, onions, scurvy-grass, mustard, &c. produced by putrefaction from animal or vegetable subjects, or procured from the same by distillation and burning.

4. Certain bodies improperly called alkalies, only on account of agreeing therewith in fermenting with acids; these are almost all the boles, bones,

chalk, clays, coral, crabs-eyes, earths, horns, hoofs, nails, pearl, shells, stones, and teeth.

5. The seven metals.

6. The semi-metals, antimony, bismuth, *lapis calaminaris*, *lapis hæmatites*, lime, &c.

7. Hence we have four general rules, *viz.* (1.) The bodies of the first class almost constantly make an effervescence with those of the second and third, either sooner or later, more or less, or as they are weak or strong. The effervescence continues till the point of saturation is gained, then ceases, and the acrimony, after a full saturation, is generally softened. (2.) The bodies of the first class make an effervescence with those of the fourth, tho' only some with others, and not universally, some stronger and some weaker; and at the end of the saturation vitriols are usually produced. (3.) The bodies of the first class act in the same manner with those of the fifth. (4.) The bodies of the second, third, fourth, and fifth classes, being mixed together, are scarce found to make any effervescence. Hence acids have this effect in particular along with the rest; tho' here also it is limited. The best spirit of vinegar poured upon oil of tartar *per deliquium* makes no effervescence at first, but does afterwards, and weakens the alcali.

8. Pure volatile alcali, well freed from its oil, makes an effervescence with pure distilled vinegar: but much more cold than heat here arises; whereas other effervescences usually produce various degrees of heat, up to that even of actual flame. This extraordinary experiment shews, that apparent motion may be increased, and attended with cold*. Other effervescencies are almost ever attended with heat†.

9. There are some moist and cold bodies which produce fire upon the instant of mixture. Put a drachm of recent distilled oil of cloves into a dry and hot urinal, set it under a chimney, and pour to it all at once two drachms of *Glauber's* strong spirit of nitre, upon the contact there instantly arises a terrible effervescence, with thick fumes, possessing the whole cavity of the glass, a true and very red flame appearing in the middle: and, when the effervescence is over, an extremely light and spongy matter is found left behind‡. In this case a very powerful acid, especially that of nitre, and a very rich oil concur, and not an alcali and acid. Mr. *Homburg* has explained the other effervescencies, some of them burning, and some almost burning§.

10. There also arises a spontaneous effervescence betwixt two hard and cold bodies, *viz.* Iron and sulphur ground together, and brought with water into a paste, which will take fire, and even flame.

* See the chapter of Fire, and *Philos. Transact. Lowth. Abridgm. Vol. III. p. 354, 356.*

† See the chapt. of Fire, p. 365—379.

‡ See *Philos. Transact. Lowth. Abridgm. Vol. III. 353—365*, and *Hoffman, Dissert. Phys. Chym. p. 38—45*, and 126.

§ See *Memoir. de l'Acad. Roy. ann. 1701. p. 84, 95. & ann. 1708. p. 2.*

A short recapitulation of the doctrine of Acid and Alkali.

ALKALI is either a fixed or volatile salt. It is known, (1.) From its origin, by the means of fire, putrefaction, or mixture. (2.) From its matter, whether vegetable, animal, or fossil. (3.) By its effect, or making effervescence with acid, precipitating, uniting with oil, especially a solution of sulphur; by changing the colour of the sun-flower, roses, or violets to green; whereas these change red with acids; by its taste, and by the burning pain it gives.

ACID is a fixed, or volatile salt, and known, (1.) from its origin, whether native, by fermentation, or by fire. (2.) From its matter, whether vegetable or mineral. (3.) From its effect, or effervescence with alcalies, earthy bodies, shells, corals, &c. by precipitating, turning neutral with alkaline and terrestrial bodies; by dissolving, especially the mercurial part of metals; changing the colour of sun-flower, roses, and violets to red; by its taste and odour, and the gnawing, darting pain it occasions.

This doctrine can scarce deceive much, but should not be rashly extended. It is erroneous to infer the existence of alkali or acid by any one physical character, which is common to other things, and even to those where any alkali is present. For example; it is a false conclusion, that because alkali makes an effervescence with spirit of nitre, but silver makes an effervescence with nitre, therefore alkali and silver are the same thing. And yet we every where find great men committing this childish error; so that they give every thing the name of an alkali, which makes an effervescence with any acid. This is a gross absurdity. Gold makes an effervescence with the acid spirit called *aqua regia*; therefore, they say, gold is an alkali: but it makes no effervescence with the acid spirit of nitre, and therefore it is no alkali. But these errors are infinite. It is a strange empty notion, to introduce acid and alkali for explaining the nature of all things; and yet we have seen the time when this doctrine has been triumphant, and thought the glory of the age. Let Mr. Boyle and Doctor Bohn be consulted upon this subject.

The production, destruction, and change of Tastes and Odours.

WE have seen these changes from our first process to the last; and there is scarce any one wherein something of this has not appeared. See Mr. Boyle in his treatise of the production of sensible qualities.

The production, destruction, and change of Colours.

1. **A**Ntimony, of itself, is black when ground; of a greenish yellow when calcined with *aqua regia*; white, red, yellow, greenish, and black, when sublimed with sal-ammoniac; of an uniform red, when freed from its salt with water, but white when fixed with thrice its weight of nitre. Thus we have almost all colours in one solid body. Quicksilver dissolved by *aqua fortis*, and distilled in a glass-retort, affords in different parts of the glass different colours.

2. To

2. To produce a black colour, by pouring a pellucid liquor into a clean glass. This is done by rinsing a clean hot glass in a strong solution of the vitriol of iron, then pouring therein a warm infusion of bruised white galls in fair water, made so weak, as scarce to afford any colour. Thus a black mixture is instantly made. Instead of galls may be used red roses, pomegranate-bark, tea-leaves, sage, or oak-leaves, for the same purposes.

3. By the addition of a little white powder to turn a pellucid liquor black. Put a hot weak pellucid infusion of galls into a glass, throw into it a grain of the vitriol of iron calcined to whiteness, and heated. This, where it falls, makes a black cloud, that, in a pleasing manner, diffuses itself thro' the transparent liquor, and gradually turns it black all around.

4. The same is done by the addition of a little yellow powder, by using as much vitriol calcined to a yellow colour, or else the yellow *ens veneris*.

5. The like may be done with a little red powder, by using the colcothar of vitriol calcined to redness, or the red *ens veneris*.

6. To do the same by the addition of a pellucid drop: let fall a drop of the aqueous solution of the vitriol of iron into the hot solution of galls.

7. To do the same with a drop of gold-coloured liquor; use the golden tincture made with the red calx of the vitriol of iron, with the dulcified spirit of salt. In all these experiments, whilst the liquor changes from limpid to deep black, there arises almost innumerable shades, or intermediate colours, which at length all terminate in black.

8. The black colour, produced in all the six preceding cases, may be brought back to pellucid again, by pouring the black liquors hot into a glass rinsed with the pure oil of vitriol, which attracts the iron: but the black liquor made with the *ens veneris* remains somewhat reddish; and so does that with the calx of iron, whilst they tend to transparency.

9. To make these transparent liquors black again, pour as much hot oil of tartar *per deliquium* thereto, as may saturate the acid which had attracted the metallic matter: this happens with an effervescence, which in the mean time reduces, destroys, and regenerates vicissitudes of colours. This is best perceived by letting the alkaline liquor fall in at several times, but quick.

10. Again; if a sufficient quantity of acid be added to the black liquor thus regenerated, so as to abolish the alkali, the whole becomes pellucid again: and thus the blackness may be reciprocally destroyed and regenerated. Hence appears the incredible power of a metal to produce blackness; and how little matter is required to the production of colours. And hence, by a careful eye, may be observed numerous intermediate colours betwixt limpid and deep black.

11. To generate a colour by pouring a limpid liquor into a clean glass. Take a strong solution of quicksilver made with spirit of nitre, dilute it with water, pour it into a hot glass rinsed with strong spirit of sea-salt. A very dilute solution of silver made in spirit of nitre, poured into a like glass, and the oil of antimony poured into a glass rinsed in hot water, does the same.

12. To produce an orange-colour, by pouring a pellucid liquor into a clean glass. Pour hot water upon new-made *crocus metallorum*, and put it into a clean glass rinsed with an acid.

13. To make a gold-colour by pouring a limpid liquor to a grey powder: Pour hot alcohol to sulphur melted with fixed alcali, then ground and made hot.

14. To change the preceding gold-coloured liquor into a milky one, by pouring it into a clean glass. This is done by putting the preceding tincture into a glass rinsed with oil of vitriol.

15. To turn an almost limpid liquor blue. Pour spirit of sal-ammoniac to a solution of verdigrease in vinegar, and dilute it with water till it be almost limpid.

16. To turn a blue liquor pellucid: Add acid to the preceding mixture, till the acid predominates.

17. To turn a very green liquor of a beautiful violet-colour. To a high green solution of copper in vinegar, drop spirit of sal-ammoniac, till the alcali predominates.

18. To turn a blue into a beautiful green. To a rich solution of copper in spirit of sal-ammoniac, add vinegar, or any other acid, till the acid predominates.

19. To produce numerous blues, and greens betwixt a deep blue and a deep green. Put a strong and hot solution of copper in sal-ammoniac, into a clean cylindrical glass; add thereto, slowly, spirit of nitre by a drop at a time; and a different colour between the two degrees assigned will appear upon the addition of each drop.

20. But for this subject of colours, Mr. Boyle has beautifully prosecuted it by experiments in his book of Colours. It is enough for me to have produced a few examples: and here I conclude the whole, and wish it may redound to the service of mankind.

F I N I S.

THE UNIVERSITY OF CHICAGO

APPENDIX.

345

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THE author having chiefly confined his sett of processes to the service of medicine; students are hence too apt to imagine themselves possess'd of the elements of chemistry at large. In order to set this matter right, and at the same time do justice to the art, it has been thought proper to add the two following essays, by way of appendix, to shew the general nature, or great extent of chemistry.

ESSAY I.

An ESSAY, for the farther Advancement of CHEMISTRY.

INTRODUCTION.

1. **A** Consideration of chemistry, in its proper extent and necessary relations, may perhaps shew it to be of that use in life, as to deserve a particular regard. *Chemistry not to be disregarded.*
2. Chemistry may be conceived as the business of changing the internal structures, or sensible qualities, of all the bodies produced by nature, by art, or by accident, in this globe of ours; with a view to search into their secret relations, so as to find out some new properties or uses thereof, and thence increase our knowledge of these bodies, or render them, one way or other, more serviceable in life. *General definition.*
3. If this description be just, it will follow, that whoever would understand the import and business of chemistry, must view and consider it in a state of action and manual operation; or, as it practically contributes to enlarge the understanding, supply the necessities, and afford the conveniences of life: which is the light wherein the Lord Verulam, and Mr. Boyle have justly placed it.
4. To give a fair and full representation of chemistry, in so extensive a view, must be the work of ages: and before any step can be taken in it to satisfaction, the subject requires a division into several branches; each whereof being gone over a-part, may give some general notion of the whole.
5. The most useful division seems aptly to fall under the comprehensive heads, or titles, of philosophical, technical, commercial, and oeconomical chemistry. *And general division of the art.*

S E C T. I.

Of Philosophical CHEMISTRY.

*Philosophical
chemistry ex-
plained.*

1. **P**hilosophical chemistry is that particular part, which, contented with things entertaining, satisfactory, and instructive to the mind, does not directly and solicitously endeavour after such as are immediately useful, or advantageous.

2. In this view, philosophical chemistry will consist of three parts, *viz.* invention, rationale, and experiment: whence it might be defin'd, the particular exercise of the inventive and rational faculties of the mind upon chemical subjects, operations, and effects, leading up to experiments and back again; so as to draw conclusions, explain phenomena, start problems, and attempt their solution, in this circle successively.

And divided.

3. Philosophical chemistry, therefore, is the source and soul of the whole art; as by inventing, reasoning, comparing, and adjusting of things, directing experiments, and concluding from the result, it forms new doctrines, and makes new discoveries, for itself, and all the other branches, to improve and apply.

*Applicable in
the way of in-
vention.*

4. In the way of invention, this part of chemistry is more particularly applicable; (1.) To the imitation of natural and artificial things. (2.) To the production of new artificial bodies. (3.) To the starting of new arts and trades. And, (4.) To the supplying of desiderata, or defects in the old ones.

*To the imita-
tion of natu-
ral and arti-
ficial bodies.*

5. (1.) Since natural bodies may be so resolved, or taken to pieces, as, in many cases, to discover their constituent parts, or ingredients; philosophical chemistry hence forms rules for imitating various productions of nature: which, in some particulars, is done to great exactness; as in the making of cinnabar, vitriol, &c. where the resolution has been found easy; in others less exactly, where, by the common methods, the resolution has hitherto proved more difficult; as in the business of artificial gems and metals. (2.) The like also is to be understood of artificial bodies, made in one country, and imitated in another; whence the imitation of *Venice-glass* in *England*, the imitation of porcellane, the *Japan-varnish*, various refinements of foreign drugs, sugar, &c. in *Europe*; all which, where not casual, are of pure chemical extraction: and the proper enquiries into things of this kind, fall under the inventive part of philosophical chemistry.

*The produ-
tion of new
artificial bo-
dies.*

6. (3.) New artificial bodies are chemically producible *ab origine*, either in the way of separation or combination. In the way of separation, chemistry has invented and produced fermented potable liquors, inflammable spirits, salts, sugar, pot-ash, those vulgarly call'd chemical preparations, as oils, extracts, spirits, &c. various pigments, and all the pure and unmix'd metals: and in the way of combination, it has produced soap, glass, vitriol, gun-powder, all the mix'd or artificial metals, &c.

7. (4.) Arts and trades are the genuine fruits or consequences of the preceding discoveries: in which view inventive chemistry is the purveyor to all the other branches; and has thus struck out a very large number of hints, which are frequently form'd into trades. Thus the invention of *aqua fortis*, for example, has given rise to the scarlet-dye, the business of etching, the art of refining, &c.

The starting of new arts and trades.

8. (5.) And as inventive chemistry thus strikes out new arts and trades, 'tis no less capable of discovering means to promote them, or supply the defects which may appear in their first establishment, or retard their farther advancement. Instances of this kind are every where to be met with; particularly in the arts of sugar-baking, soap-boiling, brewing, distilling, &c. wherein many shorter and better methods of working have hence been severally discover'd.

And supplying their deficiencies.

9. In the way of rationale, philosophical chemistry is particularly applicable; (1.) To the accounting for natural and artificial phenomena, and effects. (2.) To the explanation of the general and particular properties, or forms and qualities, of bodies. (3.) To the discovery of the chemistry of nature. (4.) To the consideration of natural and artificial transmutations. And (5.) To the giving a rational theory of medical matters.

Applicable in the way of rationale.

10. (1.) Philosophical chemistry accounts for many natural and artificial phenomena and effects; as it is often in the power of this art to imitate the same: and thence, reasoning by just analogy, it may be allow'd to give fair and satisfactory solutions. After this manner it endeavours to account for lightning and thunder, with their surprizing effects; the *aurora borealis*, earth-quakes, vulcano's, &c. And in the same way it solves the phenomena of gun-powder, the *phosphori*, and various other unexpected productions of chemistry itself.

To the solving of natural and artificial phenomena.

11. (2.) As this part of philosophical chemistry is used to explain the general and particular properties, or forms and qualities of bodies, it considers heat, cold, light, moisture, dryness, volatility and fixedness, fluidity and firmness, continuity and contiguity, colours, tastes, odours, congelation and congelation, effervescences, fermentations, putrefaction, solution, precipitation, and the various operations of chemistry, &c. so as to shew how they are produced, affected, altered, or changed in bodies; and thence draw out their general and particular histories.

Giving the histories of qualities.

12. (3.) Philosophical chemistry finds many reasons for allowing a chemical agency in the production of natural bodies, and in their manner of acting upon one another; whence they bring about a kind of true chemical effects. And upon this foundation, the original composition and structure of natural bodies is rationally accounted for; with the operations and effects of the elements upon each other. Thus water and air may be chemically considered as two grand menstruums of nature, which by means of the sun's heat, and the subterraneous warmth, are continually at work upon all sub-lunary bodies, in order to bring forward various changes, regenerations and transmutations, &c. whence the origin and appearances of meteors, the generation of hail, snow, rain, metals, minerals, &c. And thus all nature's processes of vegetation, animalization and mineralization may be considered and accounted for, as operations or effects of natural chemistry.

Discovering the operations of nature.

*Considering of
natural and
artificial
transmuta-
tions.*

13. (4.) The business of natural and artificial transmutations falls the more particularly under the rationale of chemistry, as little else besides consideration and reasoning is required to understand and apply it. These transmutations may be entirely natural, or entirely artificial; or partly natural and partly artificial. Under the entirely natural, come such as those produced by putrefaction, long standing or digesting in the air, water or any natural fluid; whence animal substances are converted into vegetables, wood into stone, metals into one another, bodies into air, water, fire, &c. and these are again into bodies.

14. The transmutations effected by the joint concurrence of nature and art, are such as those made by fermentation; where art puts the subjects together, and rightly disposes them; but nature performs the business: so in the making of paper, art stamps the rags; but nature half putrefies the matter, and thus contributes to change it.

15. The transmutations purely artificial are such as those made by triture, mixture, long digestion, and other chemical operations; as in extracting the mercuries of metals, and several other instances of the sublimer metallurgy.

16. Whether these artificial transmutations be real or only apparent, is not so much the question; those who will not allow them for transmutations, may call them alterations or changes of one form into another: and perhaps they may be no more at the bottom; for if the changed body be not always artificially reducible to its pristine state again, (which is supposed the criterion of an artificial transmutation) this may be owing not to any impossibility in the thing; but to the want of a suitable method for doing it.

*And settling
the theory of
physic.*

17. (5.) A just theory of many medical matters will naturally flow from the foregoing considerations, or from a particular application of the rationale of philosophical chemistry to the human body; with a view to observe its natural state, its disorders, and the effects of remedies. Thus in particular it helps to clear up the disputes about animal digestion, chylicification, sanguification, nutrition, &c. and may shew how the blood and humours are altered by heat, cold, motion, attrition, &c. whence the origin, nature, duration and phaenomena of distempers, and their manner of cure, might be rationally deduced.

*Applicable,
in the way of
experiment, to
the establish-
ing a theory of
chemical mat-
ters.*

18. In the way of experiment, philosophical chemistry is universally applicable, and often absolutely necessary to the farther examination, illustration and confirmation of the preceding parts, or the whole theory of the art; which cannot subsist without it. For tho' some kind of theory might be formed of philosophical matters independant of experiments; yet such theories have usually been found barren, unsound or useless, so as in no respect to be safely trusted.

*Bringing in-
ventions to
the test.*

19. It is the peculiar province of this part of philosophical chemistry, to bring new inventions and theories to the touch-stone; discover their validity or their insufficiency; and when found just and solid, to confirm or stamp them with a character that makes them universally current, and fit to be employ'd for farther uses.

*The advan-
cing of new
grades.*

20. Thus, when any hint is started for a new trade, or chemical method invented for the improvement of an old one; before the least attempt is made

made to apply it in business, the proper essay or experiment must be performed; which proving successful, upon repeated examination, with due variation of circumstances, may now encourage the application, or advancement of this discovery into an art.

21. And thus philosophical chemistry works in miniature, to try the truth, and find out the practicability of things; an example or model of which is preserved, and particularly retained, in the business of assaying; which before-hand determines the yield of an ore, and sometimes the best way of working it in large, by previous experiments made in miniature. *And finding the practicability of Things.*

22. By thus confining it self to work in small, or in the way of trial, enquiry or specimen, philosophical chemistry has the opportunity of fully commanding its subject; which it chuses of a proper size for the external senses to view, and examine on all sides; and observe the phenomena, effects and relations, without being oppress'd with too unwieldy a bulk, or having the mind distracted with too many considerations, which might attend a large work, and retard its advancement to a stated perfection. *Advantages of philosophical chemistry.*

23. But when thus the experimental part of philosophical chemistry has perfected any discovery, in small, with relation to arts or trades, and clearly shewn how it may be wrought to advantage in large, it has now performed its office; and here leaves the thing, or turns it over to the other branches of chemistry, whose end is advantage, to be carried on in the form of a business. So *Cornelius Drebbel*, when he had fairly proved the invention of the scarlet-dye, gave it up to those who afterwards exercised it as a trade. And this appears to have been the general way wherein arts and trades were originally invented, or first brought into use; for it cannot be supposed, that large expensive works should have been set up, before any trial had appeared to encourage them. *Contributes to establish larger works.*

24. 'Tis a particular happiness in this business of experiments, that when an enquiry is made by their means, a proper sett, or competent number of them, gone thro' in due order, will usually give the discovery, or as it were a spontaneous solution of the problem. But to practise this method to advantage, requires a judicious head and a dextrous hand; with a due observance of the rules laid down by the Lord *Verulam*, in his *Novum Organum*. *In what manner to be prosecuted.*

25. As the several parts of philosophical chemistry are thus separately applicable to such purposes; much greater advantage may be reasonably expected from the joint use and mutual assistance which they are capable of affording each other; especially by a prudent management and application. Much has been done in this way, but more remains to do. The Lord *Bacon* seems to have gone as far as possible, without the assistance of new experiments, in all the parts of philosophy, but principally in chemistry; up to which his attachment to nature directly led him; but at the *fact experimentum* he judiciously chose to stop, rather than to advance farther by the help of conjecture, or supposing the event of experiments which it would require some ages to make. As if the *fact experimentum* had been directed to Mr. *Boyle*, this philosopher took up chemistry, where the Lord *Bacon* left it; and to what lengths he carried it, the present state thereof may witness. *The joint use of parts of philosophical chemistry.*

26.

Chemistry cultivated in Germany,

26. But the *English* philosophers seem at present to be got a little out of this chemical vein; and applying closer to other studies, leave the cultivation of chemistry to the philosophers of other nations. We have had our *Bacons*, our *Digbys*, and our *Boyles*; men as eminent in chemistry, as in other parts of knowledge: but *Germany* seems more disposed to encourage this art, where every court has its laboratory, and every mountain its mine; whence that country has been usually well supplied with original chemists; such as *Agricola*, *Ercker*, *Kunckel*, *Becher*, *Homburg* and *Stahl*.

And Holland.

27. Hence also their contiguous neighbours, the *Dutch*, have derived so much of this art as suits their purpose; and fits them to supply all *Europe* with commodities of great consumption, new fabricated and refined by their industrious hands. Nor has less industry been used of late, to promote the knowledge of this art in their Universities; and tho' it be there taught with a view to medicine only, yet some have hence taken occasion to launch a little into philosophical chemistry.

Extent and office of philosophical chemistry.

28. But not to leave this business of philosophical chemistry too loose, it may be necessary to curb and confine it within its own bounds; so as to keep it from entrenching upon the exercise of certain mechanic arts, or trades, on the one hand; and upon the common experimental philosophy on the other.

Distinguished from arts.

29. Philosophical chemistry seems sufficiently distinguished from the exercise of arts by the observation already made, of its being confined to work in miniature, by way of inquiry, trial and specimen only; whereas arts produce in large, upon a formed and settled discovery, to supply the demands of trade and the calls of commerce. So that, for example, there is the same difference betwixt a substance produced in a chemical experiment, and a commodity produced in the way of an art, as betwixt the assay of an ore in a private chamber, and the working of the ore for its metal in the smelting-huts. The distinction might otherwise appear from the invention, discovery and reasoning which constantly precede and direct all the original chemical experiments; but are wanting in the exercise of arts: which have all that done to their hand; and only consist in a repetition of the same uniform action, or operation.

From experimental philosophy.

30. The distinction betwixt philosophical chemistry and the common experimental philosophy lies here, that philosophical chemistry is the business of practically, or experimentally, examining into the internal structure and composition, not only of natural, but likewise of artificial and accidental bodies; separating their constituent parts, differently combining these again, and thus producing new concretes, and new modifying or changing both the sensible properties and the internal as well as external forms of the old ones; whereas the common experimental philosophy is employed in searching after and discovering the more general and obvious properties, or external uses of natural bodies; the gross integrant parts, or entire aggregates whereof it experimentally orders, arranges, disposes and applies, in their natural form and substance, to the promotion of knowledge, and the uses of life: but thus produces no new bodies, nor enters into the internal substance, structure, and composition of the old ones; nor changes their external and internal

internal forms; nor separates their constituent parts; nor variously combines these afresh; nor regards bodies at all as they are resolvable and combinable, or as they are simples, mixts, compounds, aggregates or de-compounds: all which is the peculiar business and office of philosophical chemistry.

31. Thus again, 'tis conceived that natural philosophy cannot, with propriety, be said to extract and purify metals, analyse vegetable, animal and mineral substances, tan leather, brew beer, dye cloth, make glass, produce oils, spirits, soaps, &c. but all these are the direct and proper operations of chemistry. *And from natural philosophy.*

32. So, likewise, natural philosophy discovers the obvious, external and general properties of the air, fire, water, heat, cold, moisture, wind, &c. by means of various experiments, made with the air-pump and other suitable contrivances; but it is philosophical chemistry which more intimately and essentially examines into the internal nature, structure, composition, relations and uses of the elements; and thence finds ways of applying them as engines and instruments of business: and thus, in a more particular manner, it applies those two grand instruments, heat and cold.

33. In short, there seems to be nearly the same difference betwixt chemistry and the present natural philosophy, as there is betwixt art and nature; so that perhaps it might not be amiss, if by way of distinction, the whole of chemistry were allowed to pass under the name of artificial philosophy. *The whole of chemistry an artificial philosophy.*

34. This distinction might not only serve to restrain chemistry to its proper province, and settle a just notion of the extent and proper business thereof; but in some measure also contribute to remove the prejudice convey'd with the name, and thro' habit apt to arise in the mind upon all occasions, when chemistry is mentioned.

35. The immoral practices of many who have taken up the name of chemist, greatly contribute to bring a disrepute upon the art; whereto the abandon'd and the dissolute have usually made their pretensions, with no more knowledge of it, than would serve them to cheat dextrously under its appearance. And so odious has chemistry been render'd by this means, as to deter many from the study and exercise thereof; whence it has been too much left in bad hands. But the damage from this quarter is more sensibly perceived in the sublimer metallurgy; whence golden mountains having been too often seriously expected, the indigent and knavish pretenders to the art, have hence been furnished with a handle to practise upon the unwary, or such as they found actuated by superstitious credulity, or blinded by an immoderate passion for gain: insomuch that numerous and repeated abuses, flowing from this fountain, have occasion'd the instructive, and philosophical art of alchemy, to be currently esteem'd as a juggle, or a trick, on the one side; and as an insatiation or delusion on the other. *Whence the disrepute of chemistry.*

36. These, and the like abuses, are indeed no way justly chargeable upon the art it self, but entirely upon the artists; yet such is the fate of human affairs, that the faults of men are often laid at the door of the arts they profess; as those arts may prove occasional causes of the ill: whence chemistry perhaps gives more occasion of public and private abuses than other arts; as being less generally understood, and attended with the prospect of larger profits and advantages. *Whence its farther advancement retarded.*

37. But as the best things are capable of the greatest abuse, this misapplication of chemistry could hardly, of it self, have removed it from the care and patronage of the *English* philosophers, if more tempting studies had not come in the way; particularly the higher geometry, and speculative philosophy; which of late seem to have employ'd most of our great genius's. But if upon full examination these more sublime studies shall be found of narrow use; chemistry again may chance to be cultivated, as an art whose essence is action, and whose end is utility.

*Reasons for
the revival
of chemistry.*

38. And if the genius of the *British* philosophers should in earnest turn this way, the art it self might thus be nobly rescued from the hands of such as dishonour it; and be set in a true light, unsullied by chicanery, imposition or delusion: new improvements would be daily made therein; many valuable secrets discovered; new trades advanced; commerce enlarged, and useful knowledge encreased. And tho' our philosophers were to be thus employ'd for ages yet to come, no fear of exhausting this rich mine of philosophy and arts: which may be now dug to greater satisfaction and advantage, as there is no want of mechanical hands in *England* to execute in large, or bring into works, such discoveries as shall give the encouragement. For, as much as the *English* philosophers excel in contrivance, invention and accuracy of experiment; so much are our mechanical people allowed to excel in adroitness and truth of work. And since the new opening, draining and working of mines among us, we seem to be call'd upon afresh to the exercise and improvement of this art; whence it may in time come to meet with that esteem and application it deserves in a country so justly famous as ours for its philosophy and its trade; and thence one day appear in a due body and form of artificial philosophy.

*The assistance
required
thereto.*

39. But such a fabric cannot be erected without a number of hands employed upon the several parts; and indeed all the assistance that can any way be procured, is little enough for the purpose. Nor is it easy to say, before some farther advancement is made, what materials and what helps are wanting to carry on the work. It may not, however, be amiss here to point out some of the more immediate desiderata for the farther application and advancement of philosophical chemistry; leaving the rest to be specified occasionally.

*Desiderata of
philosophical
chemistry;
with the ways
of supplying
them.*

40. (1.) And first, a method of facilitating the experimental part of philosophical chemistry is greatly wanted; and may be supplied by the introduction of a small apparatus for an extemporaneous philosophical laboratory.

41. The difficulties, inconveniences and incumbrance that attend the erecting, procuring and using the common chemical furnaces and vessels, have been found a considerable discouragement to the exercise of this art, in the way of experiment and inquiry; so that it might be of good service, if a philosophical or portable furnace were at all times easily procurable, for the ready and commodious performance of all the operations in chemistry; the furnace, with its apparatus of vessels and instruments, being made capable of standing, and working in a common room, or chamber, without danger. And whoever considers what has already been done in this way by *Glauber* and others, but particularly by *Becher* and *Vigani*, will not find reason to think such an engine and apparatus impracticable*.

* See the following Essay.

42. Along with this general portable furnace, and select apparatus of vessels and instruments, might go a suitable collection of the more necessary and useful parts of the *materia chemica*, ranged under proper classes; with their descriptions and more general uses: and thus all the preparatory matters to the exercise of philosophical chemistry, might, without farther trouble, be put into every one's hands.

43. (2.) In order to direct the more necessary inquiries, it might be useful to have a just summary of all that is hitherto known and done in chemistry, concisely drawn up, to shew the present state of the art with regard to what is delivered in books. And this perhaps would be found an easier task than it might at first appear: for tho' the authors in chemistry are exceeding numerous; yet the original experimental writers, who alone should here be regarded, are few in comparison of the speculative theorists, plagiarists and transcribers. The more difficult part of the work would be to collect from unwritten traditions; and describe the daily practices of mechanical operators in their ordinary business of smelting, refining, assaying, tempering of steel, working of glass, boiling of sugar, preparing of colours, refining commodities, &c. All which require particular managements, that the workmen in most cases studiously conceal.

44. (3.) There is farther wanting, to the advancement of philosophical chemistry, a set of practical rules for conducting all the chemical operations, and teaching the necessary encheireses or managements. For tho' a hand cannot by such rules alone, without practice, be formed to business; yet the understanding may be directed by them to procure the habit in the best and shortest manner. And, besides the usefulness of such rules to those unacquainted with chemical operations, they may be of farther advantage to persons of experience; as the failure of particular experiments, in particular hands, seems principally owing to a neglect or non-observance of particular encheireses; which, in delivering experiments, are sometimes omitted by design, and sometimes by neglect or oversight. Thus the particular success of many experiments in the sublimer metallurgy, has been thought contingent; as those who endeavour'd to repeat them could not make them succeed; but was afterwards found owing to inattention, mis-conduct, or the want of a particular encheiresis, in some part of the operation. And this kind of failure will frequently be found in chemistry, without a particular sagacity, and dexterity, in the conducting of experiments, or without a deliberate and sober regard to encheireses; which, in reality, make operations and experiments the things they ought to be.

45. (4.) Another particular wanted to the advancement of philosophical chemistry, is a general list of the chemical desiderata, or defects, in all arts and trades; with suitable conjectures at the readiest ways of supplying them, upon solid and experimental grounds. And to this might be added, by way of appendix, a list of hints for the introduction of new mechanic arts; upon the like rational and solid foundation: all which are a kind of problems, the solution whereof naturally belongs to the philosophical chemist. Thus in the iron-works, for example, it has been a desideratum to run metal from the stone without bellows; another to make malleable iron with pit-coal; and a

third to work it, or soften it for the hammer, without fire. 'Tis a desideratum in the tin-works to get the silver out of tin, as 'tis now got out of lead. In the glass-works, 'tis a desideratum to solder up the cracks or flaws in the pots, whilst detain'd in the fire; and another to make glass without veins; &c. A tasteless and inodorous wine is wanted by the vintner; and a tasteless and inodorous spirit by the distiller. The painter wants a permanent green, and the callico-printer a permanent blue colour. In short, all arts have their respective wants and defects. So, chemistry it self is greatly defective in an experimental history of general fermentation, separatory and combinatory, in subjects of all the three kingdoms; a history of putrefaction, rancidness, mustiness, mouldiness, glews, mucilages, and a thousand things of the like general nature. In particular, the sublimer metallurgy wants a more facile method of extracting the mercuries of metals; and a cheaper one for meliorations: and all the other parts seem equally defective.

Hints for new trades.

46. The hints for new trades will rise occasionally, and almost without seeking. Thus 'tis natural, from the common operations of brewing and sugar-baking, to suggest that sugar may be procured from malt, and other vegetables; that nurseries of peculiar ferments, native and foreign, may be rais'd, &c. The introduction of which new trades would also greatly alter and improve the arts of brewing, sugar-baking, &c.

Communication of trials and secrets.

47. (5.) When a general knowledge is gain'd in the theory and practice of this art, so that its uses and the manner of applying it to the purposes of life, are become ready and familiar; it seems principally necessary to its farther advancement, that there should be a free communication of experiments and trials, among a select number of persons thus qualified: for, as it is scarce possible that any single man should have a competent knowledge in all arts and sciences; so is it expedient, that as much as can be acquired should be lodged in some few, who may freely draw out of each other: whence they might be enabled to furnish, not jejune repetitions of things already currently known and practis'd; but results of new inquiries, new improvements, and methods of supplying the defects of particular arts, in the way of essays, well fraught with experimental facts, and useful discoveries.

48. Nor will such a body of men fail of procuring all the assistance that can be had from uncommon books, papers, and accounts of particular facts, and experiments; even, from such as relate to the making of malleable glass and philosophical gold, down to the little œconomical observations of spots and tarnish. The search after the philosophers stone has produced abundance of curious, and some very profitable discoveries: and the vulgar observation of iron-mould in linen has given origin to a fix'd and durable yellow, in the business of callico-printing. And in this manner, philosophical chemistry should be kept continually open, or in a state of improvement; only permitting, as it advances, that arts and trades be supplied, detached, or drawn from it occasionally.

SECT. II.

Of Technical CHEMISTRY.

1. **B**Y technical chemistry is understood the application of philosophical chemistry to the immediate service of arts; so as to invent, form, assist, promote and perfect them. *Technical chemistry.*
2. The chemical arts may be divided according to their subject-matters; or as they work upon animal, vegetable or mineral substances: whence the whole of technical chemistry will fall under animal, vegetable, mineral and mix'd arts. *Divided.*
3. To give a short view of the method wherein this subject is proposed to be treated, we shall here set down a few hints for the improvement of certain chemical arts; and first for those exercis'd on animal subjects. *And apply'd.*

I.

Hints for the improvement of certain chemical arts exercis'd on animal subjects.

The art of preparing size and glew.

4. (1.) The manner of dissolving the leather, and boiling the productions to their due consistence; with the ways of caking and drying the glew. *Size and glew-making.*
- (2.) The manner of preparing fine glews, from isinglafs, &c. for particular uses.
- (3.) An inquiry into the best methods of preventing the loss of tenacity, from the long boiling of the glew.
- (4.) The use of *Papin's* digester in the making of size and glew.
- (5.) An attempt to prepare glews from some cheap vegetable substances, without much heat.
- (6.) The manner of preparing and improving the fine animal glew, or pocket-soop.
- (7.) The natural disposition of all animal and some vegetable matters for turning to glews, shewn by experiments; with a philosophical inquiry into this business, for laying the foundation of a natural and experimental history of glews, mucilages, ropiness, viscosity, sizziness, mouldiness, &c. in animal and vegetable liquors; but particularly the blood, saliva, &c. wines, vinegars, &c.

The art of staining and working in horn, bone and ivory.

5. (1.) The ways of softening these hard animal substances; so as to render them capable of stamps, figures and embossments, by moulds and pressure. *Staining of horn, &c.*
- (2.) The chemical preparations, mixtures and treatment required in this business; so as to give a beautiful and fix'd blue, yellow, red, green, and other perfect colours, to bone, ivory, and other animal substances.

(3.) The methods of bleaching, or whitening and staining of hair, as depending on the same foundation; or the ways of turning hair of any colour at pleasure; but particularly from red to brown or black, from yellow to perfect white, &c. by means of chemical liquors, or chemical fumes, &c.

(4.) Ways of preventing the splitting and cracking of thin horn and ivory-wares.

(5.) Hints for the more advantageous use of the horner's shavings.

(6.) How far the processes for staining horn, hair and ivory are applicable to the staining of leather, wood, stone or marble.

(7.) The experiments and improvements in this art applied to promote the philosophy, or practical doctrine, of colours.

The art of tanning, and dressing of leather.

Tanning.

6. (1.) The best manner of preparing the hides and skins of animals, making the tan-liquor, putting them together, and drying the subject.

(2.) The history of the principal materials and ingredients employed in this art; their manner of preparing, extracting, condensing and preserving for use.

(3.) An inquiry into some farther uses of the tan-liquors, and the refuse stuff, after the operation is over.

(4.) The application of this business to the art of embalming, or preserving the flesh and other parts of animals, for certain purposes, by a suitable tan-liquor, and drying.

(5.) The use of this art in explaining the nature of corruption or putrefaction, either in general, or at least in animal subjects; as it supplies a simple remedy to prevent it: and hence an inquiry into the methods of applying it to other useful purposes.

The art of the skinner.

Skinners.

7. (1.) The best ways of preparing and preserving the skins of beasts and birds; with their natural furs and plumage.

(2.) How far this art co-incides with the art of tanning; and how far it is improveable by the arts of staining and dying.

(3.) The usefulness of this art in the business of anatomical preparations; and that part of natural history which more particularly relates to animals.

The art of curing and preserving the flesh of animals for food, both in a dry and a moist form; or by fumes, salts, and pickles; without indurating the subject too much, destroying its natural relish, or rendering it too saline.

Preserving flesh.

8. (1.) The improvements to be made in this art by the due use of sugar, nitre, and some diluted acid spirits.

(2.) The *Dutch* manner of pickling herrings; and the principle whereon its superior excellency depends.

(3.) The *English* manner of preparing red herrings; and the principal methods used in our own country to preserve provisions both at sea and land: with various improvements in these particulars, by the use of certain chemical or compound liquors, and particular managements.

The

The art of preparing, purifying and meliorating animal fats; as tallow, train-oil, sperma ceti, &c. so as to render them fit for the finer uses.

9. (1.) Inquiries after some particular methods of taking off the nidorous odour, and rankness of the grosser animal oils and fats; so as to render them sweet and fit, in some cases, to serve instead of vegetable oils and wax. *Refining fats,*

(2.) Methods advanced to edulcorate train or seal-oil, for the uses not only of the clothier, soap-boiler, &c. but to answer the ordinary purposes of oil-olive.

(3.) A particular inquiry into the method of purifying butter by separation, and converting it into a durable and perfect sallad-oil.

(4.) The sperma ceti candles improv'd.

The art of dying in wool and silk.

Preliminaries.

10. (1.) An account of the *materia tinctoria*, dying stuffs or dry-salters Dying-wares; with so much of their natural history as relates to this business.

(2.) The various ways of extracting the tinging parts of these ingredients; condensing, preserving and making them into colours, ready for use.

(3.) The different methods of preparing the subject, according to its nature, and fitting it to receive the dye.

(4.) The various ways of discharging the colours, once given to silks and stuffs.

The art itself.

11. (1.) The ways of preparing the several dye-liquors, for blacks, blues, reds, yellows, greens, &c. with the means of opening the colours.

(2.) The manner of applying the subject to the dye; with the particular encheireses requisite to the full imbibing and fixing the colour.

(3.) The method of washing and treating the subject when it comes out of the dye.

(4.) Attempts to improve the several branches of this business; as fulling, scouring, discharging, opening the *materia tinctoria*, condensing the tinging parts, fixing the colours, and changing them so as to imitate the finest fixed colours of the *Indies*. With a particular inquiry into the methods of improving the grain-colours, and rendering them cheaper.

(5.) To consider how far this art is applicable to the dying of leather, feathers, paper, shells, &c. with its farther uses in natural history and philosophy.

The art of converting refuse or excrementitious animal substances to chemical uses.

12. (1.) The methods of preparing nitre, sal-ammoniac, volatile salts, &c. from these animal matters. *Turning refuse animal matters to use.*

(2.) The ways of procuring nitre in the east, and several *European* countries: with a particular inquiry whether this art may be practised to advantage in *England*.

(3.)

(3.) The method of making sal-ammoniac in the *Levant*; with the ways of producing the same salt to profit in other places.

(4.) The art of making phosphorus from urine and other cheap excrementitious animal matters.

II.

Hints for the improvement of certain arts exercised on vegetables.

The art of preparing timber.

Timber.

13. (1.) The physical cause of a decay and rottenness in timber; with the artificial means of preserving it sound, stopping the rot, and killing the worm.

(2.) An inquiry into the best methods of careening and casing of ships, and preserving the timbers from the injuries of the sea.

(3.) The methods of fitting wood to endure long under ground, in watery places, or when exposed to the vicissitudes of the weather.

(4.) An attempt towards turning one species of wood into another; as the making artificial cedar, &c. from the more common sorts of timber.

(5.) The method of bending large timbers for the use of the ship-wright, &c. with the ways of repairing the damage they may receive in the operation.

(6.) An inquiry into the best ways of preparing timber, so that it shall not readily take fire; with a view to prevent conflagrations, or the firing of ships, houses, &c. and particularly to inquire whether this may not be effected by laying some certain preparation upon the wood-work; or by an artificial coating, a degree of petrefaction, &c.

The art of resolving certain kinds of wood by fire; viz. into tar, pitch, turpentine, oil of turpentine, resin, charcoal, and pot-ash.

Tar, &c.

14. (1.) The method of doing each of these to best advantage in different places; with an inquiry how far they are practicable in certain parts of *England*, and our own plantations.

(2.) A particular inquiry into the whole affair of pot-ash; with the ways of making it close, hard, and strong, in *England* and the plantations; or equal to that of *Russia*.

(3.) The different kinds of pot-ash, and kelp, of different countries; whence their viciousness, strength, and other good and bad qualities: with the best and easiest ways of proving their goodness, for the uses of the soap-boiler, dyer, glass-maker, &c.

The art of wax.

Wax.

15. (1.) The method of bleaching the common bees-wax, or turning it to white-wax; whence the art of the wax-chandler, in making the several sorts of wax-candles, sealing-wax, and compound-wax for stamps, &c. With an attempt towards lessening the price of wax in *England*; by the introduction of certain new substances, to answer the same ends.

The

The art of bread.

16. (1.) This art consider'd in different countries, as practis'd upon Bread, various mealy vegetable subjects.

(2.) The common manner of making bread in *England*, compared with that of *France*, and other *European* nations.

(3.) The methods of improving the art of bread-making, by raising nurseries of yeast, or introducing new means of preserving it fresh and sound.

(4.) This art shewn applicable also to animal subjects, with great advantage in some cases.

The art of starch and powder.

17. (1.) The common process for preparing starch, from wheat-meal, *Starch*, by fermentation.

(2.) The same process applied to other mealy, and some glutinous vegetable substances; as potatoes, rice, &c.

(3.) The method of reducing starch to hair-powder of different kinds; with the adulterations and abuses commonly practis'd in this art.

(4.) Inquiries into some more advantageous uses of the starch-maker's liquor; and methods of shortening the process.

The art of malt.

18. (1.) This art, as commonly practis'd in *England*, traced from the *Malt*, steeping-cistern to the granary.

(2.) Some improvements made therein by other nations, particularly the *Germans*, and of late among the *English*.

(3.) The methods of advancing this art still farther, and applying it to the malting of buck-wheat, *Virginia*-wheat, rice, and other glutinous grains; pulse, legumens, and some cheap feeds, or esculent roots and plants, for various purposes.

(4.) The method of drying malt to perfection, with any kind of fuel, by means of the *balneum marie*; &c. so as not greatly to alter its taste and colour.

The art of brewing and fermenting.

19. (1.) The common process of brewing for malt-liquors, improved in *Beer*, its several parts.

(2.) The use of some particular additions, in the business of brewing.

(3.) The art of fermenting by compression, recommended.

(4.) The use of hops improved, or superseded.

(5.) *Glauber's* method of condensation, shewn practicable to advantage in the business of brewing.

(6.) The best manner of brewing for exportation, and long voyages.

(7.) The improv'd state of this art in *Germany* consider'd.

(8.) The methods of reducing brew'd liquors to their least volume, without impairing their virtues.

(9.) The sophistications and abuses often practis'd in this art.

(10.) The methods of brewing to vary with the intention of the operator.

(11.)

Of Technical CHEMISTRY.

- (11.) The application of this art to various new subjects.
 (12.) The practical history of fermentation in its full latitude.

*The art of wines.**Wine.*

20. (1.) Various improvements in the common methods of preparing wines, both in *England* and in the proper wine-countries.
 (2.) Several methods of making as excellent wines in *England*, or other more northern countries, as those of the prime growths of *France, Italy, Greece or Hungary*.
 (3.) Inquiries into the true methods of producing tasteless wines, of any assignable degree of strength, or richness; and of giving them the perfect colours and flavours of any particular foreign wines.
 (4.) The methods of condensing wines, or reducing them to their utmost perfection; without admitting any superfluous part.
 (5.) The art of converting *English* cyder, and the tappings of certain trees, into tolerable wines.
 (6.) The whole business of wines shewn practicable to great advantage in *England*; whether wines be considered as natural, or artificial productions.
 (7.) Attempts to make extemporaneous wines; or to turn water into a vinous liquor of the nature of genuine wine.
 (8.) The best methods of remedying the various diseases of wines.

*The art of vinegars.**Vinegar.*

21. (1.) Shorter methods than the common of turning beer or wines into vinegar.
 (2.) An attempt to shew some profitable ways of preparing vinegar; without wine, or the trouble of brewing.
 (3.) An extemporaneous way of making vinegar by boiling the wine, &c.
 (4.) The ways of recovering decayed vinegar; and making it of any degree of strength.
 (5.) The method of condensing vinegar, or reducing it to its least volume.
 (6.) An attempt towards producing a solid vinegar; or obtaining the salt thereof.

*The art of distillation.**Spirits.*

22. (1.) Improvements of this art in its several parts; viz. brewing, fermenting, simple distilling, rectifying, and compounding; so as to make it answer the different intentions of the operator.
 (2.) How to brew in perfection for distillation.
 (3.) How to raise nurseries of yeast, and to preserve it long for the purposes of distillers.
 (4.) How to work with expedition in this art; and how to greatest advantage.
 (5.) How to make a clean malt-spirit.
 (6.) The business of proof in spirits particularly examined.
 (7.) The way of distilling wine- lees to advantage.
 (8.) The best methods of rectifying all kinds of vinous spirits.

- (9.) The best form wherein to export and preserve spirits.
- (10.) The best ways of judging the goodness and purity of spirits.
- (11.) Inquiries into the best acid, for giving a true vinosity to vulgar rectified spirits.
- (12.) The ways of colouring spirits, and fitting them for sale.
- (13.) The principal uses of the common spirits extended.
- (14.) The history of spirits, foreign and domestic.
- (15.) The method of turning common spirits into brandies, or arracs, undistinguishable from the foreign.
- (16.) The true method of working in compound distillation. This subject is treated at large, in our essay upon the business of distillation.

The art of sugar making, and refining.

23. (1.) The common process of making sugar from the natural juice of Sugar. the sugar-cane, chemically considered.
- (2.) Attempts to shorten this process.
- (3.) The whole business of boiling sugars to their proper height; the more certain ways of taking of proof, preventing of burning, and making the matter granulate to the best advantage.
- (4.) An inquiry into a method of converting the melasses or treacle into tolerable sugars.
- (5.) This art applied to honey, and other vegetable juices; with a particular inquiry whether sugar-works might not be set up to advantage in wine-countries, and countries productive of corn, or certain trees that yield plenty of a saccharine liquor by tapping.
- (6.) The art of refining sugar, into the different kinds of clay'd, lump, loaf, &c. with the methods of different countries, but particularly of Germany, for this purpose.
- (7.) Some attempts towards discovering cheaper and more expeditious ways of refining sugars, and bringing them, with ease, to a perfect whiteness.
- (8.) To shorten the process of making sugar-candy; or to perform it without heat, and the cockle-room.
- (9.) An attempt to introduce several new and profitable uses of sugars, both in England and the plantations.

The art of soap-making.

24. (1.) The common methods of making the different kinds of soap, Soap. in England, consider'd.
- (2.) To shorten the common ways of preparing the lixiviums, and the long operation of boiling.
- (3.) The methods of making the hard oil-soaps at Joppa, Venice, Alicante, Castile, and Marseilles; with attempts to produce as excellent in England.
- (4.) To prevent or take off the rank smell of certain kinds of soap, and give it any agreeable scent and colour.
- (5.) An attempt to perfect some extemporaneous methods of making either solid or liquid soaps.

Of Technical CHEMISTRY.

(6.) An attempt to prepare and introduce certain medicinal soaps, of uncommon virtues and uses.

(7.) The manner of making mild soaps for the finest lace and linens; and for medicinal uses.

The art of tartar.

Tartar.

25. (1.) The methods of producing tartar from different matters.

(2.) The vulgar method of refining tartar in *Languedoc*.

(3.) An attempt to convert red tartar into white.

(4.) The best and most expeditious ways of refining or bringing it into what is vulgarly called cream of tartar; so as to make it perfectly transparent, and clear as well as white.

III.

Hints for the improvement of certain mineral arts.

26. The mineral arts may be consider'd, as they regard salts, earths, or metals.

The art of making table-salt.

Salt.

27. (1.) The best manner of working salt from the sea-water, and salt-pits, in *France* and *England*.

(2.) The uses of the bitter liquor of the salt-pits, called *Bittern*.

(3.) The ways of refining salt, both at home and abroad.

(4.) The improvement of salt-making, by means of congelation, or freezing.

(5.) Some new methods of obtaining salt; in its greatest purity and perfection.

The art of making copperas and vitriol.

Vitriol.

28. (1.) The processes for making the common green and blue vitriols; with an enquiry into the best ways of shortening these processes.

(2.) Attempts towards an advantageous method of converting green vitriol into blue; or the vitriol of iron into that of copper.

(3.) Some particular uses of the raw-liquor of the pyrites, before it is boiled into copperas.

(4.) Uses of the refuse copperas, or cistern-bottoms.

The art of borax.

Borax.

29. (1.) A philosophical and chemical inquiry into the origin, nature, and uses of this salt, as found in the *East*; and thence brought into *Europe*, under the form of tincar or tincal. Whether it be a natural or factitious thing; with the manner of collecting, preserving and packing it up. Whether it be not naturally procurable in *Europe*. Whether the *Venetians* have any secret relating hereto. And in what condition this Affair stands with the *Dutch*. Whence the imperfect knowledge of this subject arises among the natural historians, chemists, and literati.

(2.)

(2.) Attempts to imitate this salt; more particularly with a view to soldering, and the business of metals.

(3.) The true method of refining this salt, and bringing it to its utmost purity and beauty.

The art of burning stone, and earths.

30. (1.) The best materials of lime for the uses of the builder; with the *Brick*. most perfect methods of burning the same, so as to make firm and durable plaister, &c.

(2.) The best manner of burning different clays into brick, and tile, for mortar, building, &c.

(3.) An attempt to burn brick, so as to make it resemble stone.

(4.) The way of burning alabaster, talc, &c. for plaister of *Paris*; and to make it of a stony hardness.

(5.) The art of enamelling, and the art of staining, applied to brick-making; so as to make bricks of any colour at pleasure.

(6.) The ways of burning clay-earth for manure.

The art of pottery.

31. (1.) The state of this art in different countries; as it works in clay, *Earthen* stone, and the finer earths, for the forming of vessels. *vessels.*

(2.) Attempts in *England* and elsewhere, to imitate or exceed the *Indian* porcellane; with accounts of their failure or success.

(3.) The whole business of glazing, considered and improved.

(4.) Attempts to improve upon *China* ware, by the use of some new compositions, or mixtures of earthy matters; with a particular account of the *Dresden China*.

The vulgar art of metals.

32. (1.) The business of finding, judging and digging of mines; and *Metals*. separating, purifying and working the metals, from the ore to the utensil: with the later discoveries and improvements made in this subject.

(2.) An inquiry into the best methods of working the stubborn ores; with the ways of improving the business of fluxes.

(3.) The several ways of making the compound or artificial metals; as brass, pewter, bell-metal, &c. The various method of softening, hardening, and blanching copper; and giving it the appearance of silver or gold.

(4.) Improvements in the compound metals; so as to imitate gold and silver in several works, to greater exactness.

(5.) The methods of making iron with pit-coal, and softening cast-iron; with some attempts to render iron-malleable without heat, or to make it work like copper.

(6.) Attempts to separate silver from tin; and to find if any proportion of the tin be convertible into silver.

(7.) The chemical history of solders; with improvements in this useful branch of metallurgy.

(8.) The best methods of tinning iron-plates, copper-plates, &c.

Of Technical CHEMISTRY.

(9.) An inquiry into the nature, phenomena and effects of Stahl's phlogiston, or unctuous principle, in the affairs of metals.

(10.) The business of gilding and washing of metals.

(11.) An inquiry into the methods of making the red and white copper of Japan.

(12.) The more certain methods of detecting adulterations and abuses in metals.

The higher art of metals.

Alchemy.

33. (1.) Attempts to procure the mercuries of the several metals.

(2.) A set of new experiments to shew whether one metal is transmutable into another.

(3.) Some endeavours to fix common mercury into a metalline or ductile matter; and to soften the regulus of antimony.

(4.) The common method of turning iron into copper examin'd.

(5.) Mr. Boyle's method of transmuting gold into silver examin'd.

(6.) A summary view of the sublimer metallurgy in all its parts; with particular observations and improvements upon such things therein as appear solid and useful.

The art of smithery.

Smithery.

34. This art chemically considered in the hands of the goldsmith, silversmith, copper-smith, tin-man, pewterer, plumber, and iron-smith; with some attempt to supply their respective desiderata.

The art of foundery.

Casting.

35. (1.) To find the best mixtures and methods for casting large ordnance, bells, &c.

(2.) Inquiries into the most direct means of making the metal run smooth, close and found.

(3.) The common business of foundery in brass, improved.

(4.) The ways of casting iron-guns, stove-backs, &c. at the iron-furnace; with a view to their improvement.

The art of practical mineralogy.

Examining minerals.

36. (1.) Chemical methods of examining the various mineral bodies; to discover their natures and contents.

(2.) The principal uses of such bodies as cadmia, arsenic, mundic, yellow zink, &c.

(3.) The various metallic compositions to be made with them; and the manner wherein they affect and alter the perfect metals.

IV.

Hints for the improvement of certain mix'd chemical arts.

37. By mix'd arts we understand those which are exercised upon subjects of more than one of three classes at once; as upon animal and vegetable subjects together.

The

The art of paper, in wool, silk, and linen.

38. (1.) The common methods of making the different kinds of paper. *Paper.*
- (2.) This business considered, with a view to shorten and improve the process.
- (3.) The methods of making the whitest paper, and giving any kind of colour thereto; with the usual method of making that called marbled-paper; with its improvement, both at home and abroad, &c.
- (4.) Some attempts to render paper more durable, and less apt to be gnaw'd, or torn by domestic animals, &c.
- (5.) The state of this art in *China, France, Holland and England.*
- (6.) The ways of embossing and printing of paper for hangings, &c.
- (7.) The application of this art to the *asbestos*, so as to make incombustible paper.
- (8.) An attempt towards a method of discharging the printers ink out of paper.
- (9.) The best way of making filtering-paper for chemical uses.
- (10.) New kinds of paper for cartridges, hangings, &c. that shall not take fire.

The art of inks.

39. (1.) Ways of preparing solid and fluid inks, of all colours. *Inks.*
- (2.) Methods of discharging most kinds of ink.
- (3.) Ways of recovering the colour of decay'd ink; so as to render old and almost effaced manuscripts legible.
- (4.) The sympathetic inks consider'd.
- (5.) The printers ink improved.
- (6.) Ways of curing the imperfections of the common writing-ink, so as to render it undischageable; preserve it from ropiness, mouldiness, and being prey'd upon by time, and vermin, that would otherwise destroy the paper.

The art of japanning.

40. (1.) The state of this art in *England*; with its means of improvement. *Varnish.*
- (2.) An attempt to introduce the amber-varnish, so as to give a thick coat of real amber.
- (3.) The japanning of *Europe* compared with that of the *East*.

The art of glass.

41. (1.) The common processes for making the different kinds of glass, *Glass.* examin'd.
- (2.) The state of this art in different countries.
- (3.) The late improvements in the art of glass, carried still farther.
- (4.) Attempts to prevent veins in the finer glass.
- (5.) Attempts to discover some material for the glass-house pots, not subject to crack or flaw in the fire.
- (6.) The most practicable ways of stopping such cracks, when they happen.
- (7.)

Of Technical CHEMISTRY.

- (7.) The methods of staining and colouring glafs.
- (8.) The ways of imitating gems in glafs.
- (9.) Attempts to make glafs approach the hardness of the diamond.
- (10.) Attempts to mollify glafs, or render it in some degree malleable.

*The art of pharmacy.**Medicines.*

- 42. (1.) The present state of chemical pharmacy consider'd.
- (2.) How far it obtains, and how far it fails of obtaining the specific virtues of the *materia medica*.
- (3.) Attempts to introduce various new and effectual methods of treatment into this art; with a view to procure the real virtues of simples, and render them specific.
- (4.) An attempt to regulate and ascertain the business of composition in this art.

*The art of pigments.**Pigments.*

- 43. (1.) This art considered, in the hands of the dry-salter, colour-man, and painter.
- (2.) The best and shortest methods of preparing the several pigments; as white-lead, red-lead, the lakes, the blues, the greens, the reds, &c. with the ways of grinding, mixing and fitting them for the painter's pallet, and other uses.
- (3.) Attempts to introduce several new kinds of artificial pigments.

*The art of fire-works.**Fireworks.*

- 44. (1.) The best methods of preparing gunpowder, for its several uses.
- (2.) Attempts to make the whole parcel of gunpowder take fire instantaneously in large charges.
- (3.) Some attempts to improve gunpowder, and increase its force; with the best ways of preserving it from accidents.
- (4.) The whole business of fire-works consider'd.
- (5.) Some attempts to imitate the phenomena of the sun, &c. by fire-works.
- (6.) An inquiry into the Chinese method of fire-works.

*The art of printing on Callico, and linen.**Staining.*

- 45. (1.) The usual methods of preparing the subject, laying on the colours, or giving and fixing the stain.
- (2.) An inquiry into the durability, nature, and changes of these colours; and the ways of discharging them.
- (3.) The ways of imitating the fine fix'd reds and blues of India.
- (4.) The chemical history of stains and mildews.
- (5.) The chemical history of madder; and its uses in this art.
- (6.) The several colours, at present used in callico-printing, how prepared, and improved.

(7.) An attempt to supply the defects of this art; by striking certain stains, without the assistance of alkali and acid.

(8.) An inquiry into the state of callico-printing in the *East-Indies*; and the chemical artifices there used for the purpose.

The art of printing on paper, with metalline types.

46. (1.) The best ways of preparing, casting and working the mix'd Printing-metal for printers types; so as to give the letter a full face.

(2.) The most expeditious methods of cleansing the forms.

(3.) Attempts to improve the printer's varnish.

(4.) Certain attempts to improve the printer's ink.

47. Besides the various arts of this kind, which seem more directly chemical, there are many others capable of receiving improvement from chemistry; and among these may be reckon'd painting, sculpture, statuary, architecture, agriculture, husbandry, navigation, astronomy, and all the practical arts, both of peace and war.

48. Upon a slight survey of the present state of the chemical arts in *England*, there appears to be room for the introduction of several new ones; and, among others, the following.

(1.) The refining of animal fats, for curious uses.

(2.) The making of sal-ammoniac from refuse matters.

(3.) The improved method of refining camphire.

(4.) The refining of tartar, into beautiful crystals.

(5.) The refining of coarse manna.

(6.) The improvement of *Epsom* salt.

(7.) The compleating of borax; or the perfect manner of refining tincal.

(8.) The boiling down malt-wort to a treacle, for distillation, brewing, and exportation.

(9.) New art of brewing, with cheap materials.

(10.) New art of wines.

(11.) New art of vinegars.

(12.) New art of producing, and rectifying spirits.

(13.) The perfect imitation of *French* brandies, and *Indian* arracs.

(14.) The preparing of new *English* brandies, and *English* arracs.

(15.) The raising nurseries of ferments, of different kinds.

(16.) The art of recovering eager wines, and musty drinks.

(17.) New manufacture of wine-lees.

(18.) The manufacture of white-lead, without vinegar, horse-dung, or grinding; or without prejudice to health.

(19.) The making of *English* liquorice.

(20.) The making of *English* opium.

(21.) The art of teas.

(22.) New art of snuffs.

(23.) The making of oil-soap.

(24.) The making of blue vitriol.

Of Commercial CHEMISTRY.

49. The several preceding articles are not here propos'd as bare hints only, or superficial glances unwarranted by experiments or observation; but as an intimation of some advantage to be rationally expected from a due prosecution of the subject.

S E C T. III.

Of Commercial CHEMISTRY.

Commercial
chemistry.

1. **BY** commercial chemistry is meant the application of philosophical and technical chemistry, to the founding, supporting, and improving of trades and commerce.

Its parts.

2. In this view commercial chemistry will consist of three principal parts; viz. (1.) The exercise of all the chemical arts in such a manner as to supply beyond the demands of a single nation; and afford a surplus of commodities for exportation, and foreign consumption. (2.) The several ways of condensing, curing, preparing, securing and fitting natural and artificial productions, or commodities, for transportation and carriage. And (3.) The means of supplying the chemical necessities to voyagers, and travellers, for founding, supporting and improving trade, traffic, and commerce in different countries.

Hints for extending the chemical arts, and rendering them commercial.

How to be ex-
tended.

3. This Subject is of too complex; and intricate a nature, to be adjusted from bare philosophical and chemical considerations: a knowledge of the different policies, laws, interests, and customs of nations is here required; or the joint abilities of the statesman, and the merchant. Thus perhaps it might not, tho' it were practicable, be the interest of *England* to rival *France* in wines and brandies; *Germany*, and *Sweden* in metals; nor *Holland* in the production of corn-spirit, and the cheap preparation, or refinement, of certain other commodities.

4. But supposing *England* at full liberty, and the customs, duties and draw-backs in her favour; then it is a point of philosophical and chemical consideration, to shew what arts may be render'd commercial, for the benefit of our own kingdom. And among others of this kind may come the following; viz.

- (1.) The arts of wines and brandies; from grapes of *English* growth.
- (2.) The same arts, without grapes, to greater advantage.
- (3.) The art of producing corn-spirit, to better advantage than the *Dutch*; and under-selling them at the foreign markets.
- (4.) The art of producing vinegars, cheaper than in *France* or *Holland*.
- (5.) The art of producing arracs, equal or superior in goodness to those of *India*.
- (6.) The art of refining camphire, to greater perfection than in *Holland*.
- (7.) The art of making hard oil-soaps, equal to the foreign.

(8.)

(8.) The arts of curing several sorts of fish, and flesh, to greater advantage than in *Holland, Germany, &c.*

(9.) The art of refining borax, to greater perfection than in *Holland.*

(10.) The art of making white-lead, to greater advantage, than in *Holland.*

5. It is not necessary to be large in the enumeration of other chemical arts, no less improveable than these, for the purposes of commerce; because a single one, when fully advanced and extended, may often prove the principal business of a whole country; as the art of wines in *France, Spain, and Portugal*; the art of sugar in the plantations; the art of metals in *Germany, and Sweden, &c.* And in this large view it is that arts come to be consider'd under the head of commercial, as, in a less extensive way, they fall under that of technical chemistry; to which we therefore refer.

Considerations on the more perfect ways of condensing commodities, for exportation, without impairing their virtues.

6. Before goods are sent abroad, 'tis proper they should be reduced to the least volume they are capable of, without injury; and put into a condition of receiving the least damage from the weather, salt-water, and other accidents. Thus, metals are transported instead of their ores; sugar instead of the sugar-cane; dry raisins instead of grapes; high spirits instead of low-wines; salt instead of sea-water, &c. with care to secure each subject, that requires it, in a suitable fustage, or futail. And thus by means of commercial chemistry, different countries are supplied with pitch, tar, rosin, turpentine, brimstone, wax, oil, tallow, tann'd-hides, wines, brandies, salt, sugars, treacle, paper, lead, tin, iron, silver, &c. whereby all trade, traffic, and commerce is supported.

Commercial condensation.

Hints for the history of commercial condensation.

7. (1.) The method of condensing wines, so as greatly to lessen their bulk; and at the same time improve their virtue and goodness, and render them more durable, or less subject to change or decay, either by land or sea.

The condensing of wines.

(2.) The way of condensing malt-liquors and vinegars for exportation, in the form of a rich liquid, not subject to spoil in the longest voyage.

(3.) The art of condensing all kinds of spirits, brandies, rums, and arracs, without losing of their natural flavours, or virtues.

(4.) The art of condensing the juice of foreign grapes, and leaving it fit to be made into wines in countries that produce no wines of their own.

(5.) Methods of reducing the tinging parts of the more bulky dyeing-stuffs, to a kind of extract; for the use of dyers, &c.

(6.) The reduction of pot-ash, tincal, and borax, to a less volume, or weight; yet retaining all their essential parts.

Hints for the history of commercial curation.

8. (1.) The best ways of curing animal substances; but particularly flesh, fish, and animal oils or fats, for exportation, and long voyages.

Commercial curation.

(2.) The best ways of curing various vegetable commodities; as fruits, woods; gums, hops, tobacco, and all animal, vegetable, and mineral drugs.

Hints for the history of commercial package.

Commercial
package.

9. (1.) When goods are cured, and reduced to their smallest bulk, for exportation, the next consideration is the manner of packing them up, and securing them to the best advantage.

(2.) Goods are reducible to two species, viz. fluid and solid; according to the nature whereof, they require a different package: whence an inquiry into the best ways of securing oils, wines, brandies, treacle, malt-liquors, tar, turpentine, quicksilver, &c.

(3.) An inquiry into the best methods of securing solid, but liquifiable goods; as kelp, pot-ash, sugar, soap, nitre, vitriol, borax, alum, &c.

(4.) The methods of securing volatile and strong-scented solids; as camphire, musk, asa-fœtida, &c. so as to prevent their avolation, or affecting other kinds of goods.

(5.) The best methods of securing teas, and all fine goods, that are apt to catch and retain any heterogeneous odour.

(6.) The best ways of preparing wrapping-cloths for dry goods; as the *East-India* wax-cloth, and tutenag-canisters, the *English* oil-cloth, tarpawling, &c.

Hints for a history of the uses of chemistry to travellers, or in long voyages at sea, with a view to commerce.

Chemical ap-
paratus for
voyages.

10. (1.) The necessities for long, trading voyages shewn; as particularly a chemical chest, a portable-furnace, and a small apparatus, consisting of a screw-press for oils; of flux-powders, quick-silver, and antimony, &c. for assaying of gold, silver, and ores.

(2.) The more certain signs of mines; especially from the chemical examination of mineral waters, and the evaporation of mineral juices.

(3.) The more expeditious ways of assaying animal, vegetable, and mineral substances; to shew what proportion of valuable or merchantable commodities they hold: illustrated in oils, essences, mineral liquors, drugs, ores, and other mineral or metallic matters.

(4.) Heads of inquiries, to be made by travellers, into the productions of different countries, as particularly into the manner of preparing arracs, nitre, borax, porcellane, and the curing of teas in the *East*; making sal-ammoniac in the *Levant*; vitriol in *Germany*; brandies in *France*; pot-ash in *Russia*, &c.

(5.) An account of certain chemical contrivances, capable of deceiving travellers and merchants in the condition of commodities; with the most expeditious ways of detecting such impositions: as the sophistication of wines, brandies, vinegars, and arracs; the debasement of gold-sand, gold-bars, or ingots, silver, copper, tin; counterfeit gems, &c.

(6.) The more certain, and expeditious chemical ways of discovering the goodness, or genuineness of most merchantable commodities: with the best methods of assaying pot-ash, tinca, amber, ambergrease, musk, opium, aloes, the natural balsams, bezoars, and various other kinds of drugs.

(7.)

(7.) The more ready ways of examining whether unexperienced waters be wholesome.

(8.) The best methods of preserving fruits, flowers, and seeds in their perfection, during a long voyage.

(9.) The best methods of obtaining and preserving fresh-water at sea.

(10.) The best and most expeditious ways of edulcorating the sea-water, so as to render it potable, or fit for common uses.

(11.) The best methods of preserving fresh provisions, at sea.

(12.) The best pharmaceutical methods of curing certain diseases incident to sailors, and travellers, in long voyages, and in some particular countries.

SECTION IV.

Of Oeconomical CHEMISTRY.

1. **B**Y oeconomical chemistry, is understood the application of philosophical, technical, and commercial chemistry, to the particular uses of a family. *Oeconomical chemistry.*

2. Hence oeconomical chemistry is of great extent; as bringing into practice, tho' in a small way, most of the larger works of commercial and technical chemistry: from the latter whereof, it differs only as that does from commercial chemistry; the first producing to serve a family, the second a single nation, and the third the world. *Its uses and extents.*

3. This branch of chemistry may be consider'd with regard to the several offices of a house; wherein, as in so many different laboratories, 'tis usually practis'd; that is, with regard to the brew-house, the cellar, store-room, kitchen, dairy, laundry, and their respective stores, furniture, and apparatus.

Hints for the economical history of fermentation, or the management of the brew-house and the cellar.

4. (1.) The best methods of brewing with malt, for the service of a family. *Oeconomical fermentation.*

(2.) The method of brewing with honey, for mead, metheglin, and a liquor resembling canary.

(3.) The method of brewing with treacle, sugar, and mix'd vegetable matters.

(4.) The best method of making cyder and perry; either simple, or by mixture.

(5.) The method of brewing with some particular vegetable juices, of a saccharine nature.

(6.) Certain new methods of making particular drinks.

(7.) The art of preserving yeast, for some months, fresh and sound, for various uses.

(8.) The whole business of making perfect, sound, and wholesome wines of English grapes.

(9.) The best ways of imitating all the foreign wines, without either grapes, or raisins.

(10.) The perfect imitation of Tokay wine.

(11.) The art of made-wines, with raisins, or without, to great perfection.

(12.) Some methods of curing foul and ropy wines, and recovering eager drinks.

(13.) The best ways of defending a vault or cellar from frost; and of restoring wines or drinks that have been frozen.

(14.) The methods of preserving the casks and brewing-vessels, in their greatest purity and perfection: with certain ways of recovering musty vessels.

(15.) The best method of erecting a brew-house; so as greatly to lessen the labour and expence usually attending the making of drinks.

(16.) The art of vinegar and verjuice; from malt, raisins, wines, cyder, crabs, &c. with the best methods of making them durable, and preserving them at all times fit for use.

Hints for the history of the stillatory, and the store-room.

*The family
stillatory and
store-room.*

5. (1.) The perfect ways of making the most useful simple-waters.

(2.) The best manner of distilling spirits from the grounds of beer, ale, or wine-lees, for the service of the lamp, or the making of compound waters.

(3.) A set of the most useful cordial waters, for the service of a family; made either by distillation or infusion.

(4.) Certain easy and cheap ways of imitating French brandy, and Indian arrac, for family-uses.

(5.) The kind of still most proper for oeconomical purposes; with the method of setting and working it to advantage; especially in large families, and gentlemens country-seats.

(6.) The best methods of drying and preserving flowers, fruits, herbs, roots, and seeds, for family-uses.

(7.) The ways of preserving foreign fruits, as oranges, citrons, &c. all the year.

(8.) The art of conserving certain vegetable productions, in vinegar, or compound pickles.

(9.) The art of conserving fruits, flowers and vegetable juices with sugar; for the table, and certain medicinal uses.

(10.) The art of conserving certain animal substances with salts, sugar, and acid fumes, or smoke, for the table.

(11.) The best methods of preserving nuts, peas, legumens, &c. so to eat as if fresh gather'd.

Hints for a history of culinary arts.

*Culinary
arts.*

6. (1.) To determine the best fuel for kitchen use; and a method for rendering it cheap, and inoffensive.

(2.)

- (2.) The most expeditious and agreeable methods of lighting a fire, or warming a room.
- (3.) The best methods of preventing the inconveniences arising from smoke, foot, and effluvia in a kitchen.
- (4.) The art of edulcorating the refuse fat of a kitchen, for lamps or other oeconomical uses.
- (5.) The manner of introducing the *Balneum Mariae*, and *Papin's* digester, into the kitchen, with advantage.
- (6.) The best methods of preserving all the metalline furniture of a kitchen, from rust and tarnish.
- (7.) The method of expressing fallad-oils from various seeds; as particularly from the seed of mustard, &c.
- (8.) The method of making the finest and keenest salt for the table; with the ways of rendering it medicinal to certain purposes.

Hints for the chemical history of the dairy.

7. (1.) The chemical history of milk, and its different parts.
- (2.) Methods of procuring the largest yield of dairy productions.
- (3.) The chemical history of rennet, and certain vegetable acids, in the making of cheese and butter.
- (4.) The proper application of cold, heat, rest, and agitation in the business of the dairy.
- (5.) To determine the best kind of vessels and utensils for the dairy.
- (6.) Ways of flavouring and colouring these productions to any particular taste or fancy.

Arts of the dairy.

Hints for the chemical history of the laundry.

8. (1.) The best family methods of making soaps, for different kinds of linen and laces, &c.
- (2.) The best family ways of preparing the finest blues and starch.
- (3.) The best methods of taking spots, stains, iron-moulds, mil-dew, &c. out of linens and laces.
- (4.) The art of bleaching, or whitening of linen.
- (5.) The method of softening hard waters; or fitting them for the uses of the laundry, dairy, and the kitchen.

Arts of the laundry.

Hints for the chemical history of certain pleasurable, aconomical matters.

9. (1.) An account of several curious and useful oeconomical experiments.
- (2.) To preserve paintings, and all kinds of furniture within doors.
- (3.) To preserve wood-work, exposed to the wet and weather.
- (4.) The history of manures; and the best ways of preparing grain for the ground.
- (5.) To render potable liquors cool and pleasant in the summer, or in hot countries.
- (6.) To find pleasant and wholesome substitutes for teas, &c. in England.

Various family matters.

(7.) The history of the hot-house; with new contrivances for producing the pine-apple, coffee, and various foreign fruits.

(8.) The ways of procuring grateful odours, and re-vivifying the air in rooms, or large assemblies.

(9.) The ways of exhibiting curious chemical phenomena at public entertainments, in the way of illuminations, &c.

10. Thus we have lightly touch'd some principal heads, under which chemistry, or artificial philosophy, may be consider'd, with a view to its farther advancement. The form wherein they are spoke to, being that of hints, shews them intended for persons already acquainted with the art: as hints are more suited, and often prove more acceptable, to the intelligent in any art, than those full explanations, and deductions, which are grateful chiefly to the less knowing; who may be better gratify'd by exemplifying and illustrating the particulars here intimated. For the present, it is hoped, that any one may hence form some tolerable notion of chemistry; and become sensible of its utility.



ESSAY II.

An Essay to introduce a
PORTABLE LABORATORY:

By means whereof all the
CHEMICAL OPERATIONS

Are commodiously perform'd,

For the purposes of philosophy, medicine, metallurgy, and a family.

With SCULPTURES.

SECT. I.

PRELIMINARIES.

1. **T**HE intention of this essay is to facilitate, and promote, the practice of chemistry, by delineating a commodious laboratory; with some familiar directions for its use and application. *The design.*
2. But as the uses of the laboratory cannot be understood without some previous knowledge of the art intended to be practised with it; we shall here, by way of preliminaries, give a short view of chemistry, and point out the general manner of exercising it to advantage.
3. Chemistry is of a very extensive nature; so as to assist all the other arts and sciences: whence it may be conceived as an effective or artificial kind of philosophy, that greatly contributes to set on foot and promote the active business of the world. *Nature of chemistry.*
4. The art indeed has hitherto been little consider'd in this light; but 'tis time to advance it beyond an infant state, and introduce it farther into human affairs.
5. The works of Lully, Valentine, Hollandus, Paracelsus, Helmont, Glauber, and the generality even of the more eminent chemists, do not shew us the true nature and genius of chemistry; or the direct manner of applying it to the improvement of useful knowledge, arts, trades, and the business of men. Those authors either had not the necessary tempers or talents for the purpose; some of them wanted generosity and frankness, others a due compass of knowledge, others a clear and intelligible way of delivering themselves; and most of them wanted a tincture of the true philosophy and geometrical reasoning: so that, in general, they have amused, perplexed and puzzled themselves, as well as their readers; and thus render'd a plain and rational art disagreeably intricate and forbidding.

P R E L I M I N A R I E S.

6. But the happy philosophical temper and talents of Mr. Boyle, have clear'd us of this embarrassment; and shewn how chemistry may be familiarly practis'd to advantage: his diffusive knowledge, and sober reason, have settled the art upon its true foundation; and directed the application of it to the noblest uses. He has shewn us the method of introducing sound philosophy into the laboratory; and there applying it to business, the promotion of arts and every kind of useful science. And perhaps there is no better method than this, discoverable by human means, for the advancement of philosophy itself, and the practical inventions of men.

7. Thus, the common philosophy of our times is often explain'd, illustrated, confirmed, improved, and in some cases shewn to be insufficient, by the proper use and application of chemistry; whose peculiar province it is to separate, dissolve and compose bodies by art, change their internal texture, and give them new, sensible properties, forms, and appearances. For example, it can readily change the colours, tastes and odours of various concretes; render fix'd bodies volatile, and volatile bodies fix'd; turn fluids into solids, and solids into fluids; corrosive bodies into neutrals, and neutral into corrosive bodies; with numerous instances of the like nature; and all this by means of certain operations, the causes whereof are in the hands of the artist: whence the furnace becomes an admirable engine for philosophical inquiries. And accordingly, the uses which Mr. Boyle, M. Homberg, Dr. Stahl, and some few others have made of it, open to us a new scene of things; and shew the system of the world itself to be a kind of laboratory, where infinite operations are at once carried on without confusion.

8. And whoever desires to succeed in philosophical chemistry, might do well to imitate the authors just now mentioned; both in the business of experimenting, and reasoning upon it; which they pursue in a calm, geometrical manner, from *data* to *quæsitæ*; having previously form'd to themselves a kind of chemical algebra, whereby they soon find whether a problem be solvable, and in what manner its solution should be attempted. The excellence of chemistry lies not in hurry and multiplicity of experiments; but in a sedate and orderly performance of operations, with particular views; and coming at the end by the shortest means; all along observing the phænomena, so as to give a satisfactory cause of the effect; and shew how the discovery may turn to advantage.

9. Chemistry, practis'd in this discreet manner, seems capable of answering any expectation that can be rationally entertain'd of it: but will constantly perform less, in proportion as it recedes from so fundamental a rule. This may appear by comparing together any number of chemical authors; who are always found to succeed best in the improvement of the art, as they had a greater compass of knowledge, and a cool philosophical head. For example, let Boyle, Homberg, and Hoffman, be compared with Becher, Kunckel and Glauber, and the difference will presently appear, together with its cause.

10. The chemical analysis of so simple a thing as nitre, led Mr. Boyle into the mechanical explanation of fluidity and firmness, volatility and fixedness, corrosiveness and corrosibility, tastes and odours, and the nature of forms and qualities in bodies; all which he has given with that perspicuity and elegance,

elegance, as cannot but recommend chemistry to those who are concern'd for the improvement of philosophy. But *Becher*, with great talents and a warmer head, has run thro' many branches of philosophical chemistry, in a laudable indeed, but less distinct and perspicuous manner.

11. By means of the burning lens, *M. Homberg* has shewn, that gold and silver are as volatile at the fire of the sun, as the other metals are in our common furnaces; and adds much light to the art, by shewing how this new furnace may pave the way to a new philosophy; as the microscope and the air-pump have done in their turns (a): whilst *Kunkel* has improved and enriched *Neri's* art of glass, with several new discoveries that required less genius, and much slenderer abilities (b).

12. *Dr. Hoffman* has given us a collection of solid and useful observations, founded upon large experience, in several parts of common and philosophical chemistry: but *Glauber*, an indigested heap, or rhapsody of improvements, many of them hypothetical, or built upon slight foundations (c).

13. But for solidity of judgement, and true attachment to observation, experiment, and geometrical reasoning, in the sublimer chemistry, *Dr. Stahl*, at present seems without competitor (d).

14. And as chemistry is thus serviceable to the purposes of philosophy, *Its use to arts*; it must necessarily be as serviceable to arts; which are nothing but philosophy reduced to practice, for supplying the necessities and conveniences of mankind.

15. That the rational art of medicine has an entire dependance upon chemistry, is shewn by that great professor of both, the learned *Boerhaave*, in his elements of the art; and is farther confirm'd by *Dr. Hoffman* (e). The natural state of a living body, or what passes therein, cannot be known without its assistance. The digestion of the aliment; its conversion into chyle, milk, blood, and lymph; the generation and office of the bile; the origin of salts and oils in the blood; the great tendency of all the parts of the body to putrefaction; with numerous other phænomena and effects, require chemical explanations, before they can be satisfactorily understood. Nor are distempers to be known, and rationally cured, without the same assistance; as might be shewn in all instances, to the great advantage of physic.

16. Pharmacy is capable of receiving great improvements from chemistry; *In pharmacy*. tho' indeed this branch of medicine wants a revival, to shew how far the virtues of simples may be extracted for medicinal use, and how far the simples had better be given in their crude or natural state. This however is certain, that many of them may have their essential and more efficacious parts separated from the noxious and less useful, by means of chemistry; and thus be reduced to a commodious form for practice. In particular, a noble extract may be chemically prepared of the bark; so as to contain the full virtues of the concrete, without its woody part; which perhaps is some-

VOL. II.

C c c

times

(a) See *Memoir de l'Academ. An. 1702.*

(b) *Observation. physico-chem.*

(c) *Glauber. Opera universa.*

(d) *Opusc. chemico-physico medic. Stahliani, &c.*

(e) *Observat. physico-chem. in præfat.*

times the cause of obstructions, and other disorders charged upon the use of this remedy.

The mechanic arts.

17. As for the mechanic arts, the greatest part of them depend almost totally upon chemistry; which either furnishes them with tools and utensils, subjects or the processes themselves. Thus all metals are the genuine productions of chemistry; whence tools and utensils for all kinds of business are made. The art of glass is a mere chemical art, both in its subjects and process. Various pigments are produced by chemistry for the use of the painter; and various colours for the use of the dyer. Salt, alum, soap, vitriol, sugar, lime, brick, plaister, wines, brandies, and most of the staple commodities of *Europe*, are of the same origin.

18. Thus, if we single out any particular arts, we shall generally find that their rise and improvements were owing to some chemical discovery, or application. To instance in the art of sugar; had it not been for a chemical expedient, to make the boiled juice of the sugar-cane grain, and bring it to a dry form, we must have been contented to have used a rob, or a kind of treacle, instead of sugar; as it is said they do in some parts of the *East* to this day, for want of the art of graining. And it has been found, not only in *England* but also in *Germany* and *France*, that the greatest improvements in the art of refining sugar, have been made by such as were directed and influenced by some previous chemical knowledge.

In trades, and commerce.

19. Nor is chemistry less useful in the way of trade and commerce; as it teaches the best methods of packing and securing goods of all kinds; reducing them to their least dimensions; and preserving them from the accidents of the weather, the sea, and the like. Thus, for instance, it shews the way of reducing all ores to their metals, refuse-wood to pot-ash, spices to their essential oils, brandies to alcohol; the method of condensing wines, or bringing all their essential parts into a fourth of the whole, &c. At the same time, this art directs the package, fustage or futail, proper for every commodity, from previously knowing what bodies are dissolvable, and what undissolvable by others. Thus, to give an obvious instance, as treacle is very subject to waste, on account of the property it has of penetrating and dissolving the resinous substance of the cask, this cannot be esteem'd its best kind of futail; whence we are directed to look out for another.

Oeconomical chemistry.

20. And lastly, for the service of a family, nothing seems better fitted than chemistry; as it directs and teaches all the ways of making potable liquors, preserving meats, distilling waters, washing, cleansing, varnishing, and preserving goods of all sorts; and enters at once the whole business of the kitchen, the laundry, the store-room, the dairy, the granary, and the cellar; as has been sufficiently intimated in the preceding general essay.

21. An art of such extensive benefit might bear to be warmly recommended, especially since the generality seem little appriz'd of the nature and uses thereof; but as in all the parts of chemistry, a sedate and sober conduct is preferable to a warm and vigorous one, we shall leave the reader to his own reflections upon the farther usefulness of this art, and proceed to offer a few general directions for practising it with advantage.

22. Those who have but a slender notion of chemistry are apt to fancy *The best way of practising chemistry.* it somewhat mysterious, or at least more difficult to acquire than many other practical sciences; but a little farther acquaintance therewith will shew it to be as easy as practical geometry, or the common experimental philosophy; and obtainable by a moderate application. Nay, the great facility wherewith it may be learn'd hath occasion'd many writers designedly to disguise, perplex, and render it less intelligible; that only the worthy, as they call them, that is, those who did not want their assistance, might be benefited by it; as if all mankind had not a common right to so useful a branch of knowledge!

23. 'Tis true, chemistry, like other arts, must be conducted by certain rules, and cannot be conquer'd at once; or to say truth, is scarce to be fully master'd by human abilities: the uses and applications of it being almost endless, or its nature inexhaustible. Yet, the common qualifications of men, without any deep or intricate studies, are sufficient to carry us through an instructive and profitable course of it; tho' we should never attempt the mercuries of metals, malleable glass, or the philosophical tincture.

24. And such a course as this, any man may proceed in; either by forming rules to himself, or following those prescribed him by others. For, as the art is practical, and not capable of being carried on under wrong management; the operator presently gains light from his own errors, or instructs himself by his miscarriages. And this method, when discreetly pursued, is the best and perhaps the only effectual one of learning the art; as it fixes and inculcates things on the mind, better than verbal instruction, or bare ocular inspection; and renders a man intelligent and practically knowing in what he is about; at the same time that it procures him a talent and habit of working: which no words, descriptions, or examples could of themselves possibly do. And accordingly, the best chemists have been form'd, and the greatest improvements made in the art, by such kind of procedure. All that direction and instruction can do in this matter, is only to give the first motion to the wheel; which must afterwards be turn'd by the hand of the operator. Chemistry therefore cannot be a very difficult art, which thus teaches itself, and breeds its own masters.

25. The danger indeed attending it is greater than the difficulty; and *To avoid the dangers attending it.* may regard the person, the understanding, or the fortune of the operator. When a chemist treats certain bodies, whose properties he is unacquainted withal, or commits a mistake in an operation, the success whereof has never been tried, he may sometimes run the risk of breaking his glasses, and being offended with noxious fumes. But accidents of this kind are rare; nor is any man obliged to try dangerous experiments, or to search after such destructive or pernicious things as gunpowder and poisons. And in case any uncertain operation were to be gone upon, a little common prudence will provide against contingencies; so that the bursting of glasses, or the unexpected eruption of fumes, shall occasion no farther mischief. And as for the general operations of chemistry, the accidents to which any one of them is liable are expressly described and provided against by all good authors. So that upon the whole, chemistry is not more dangerous to the person

person of the operator than many other arts; as particularly the art of mining, fire-works, casting, building, navigation, air-pump experiments, &c. all which require to be practised with prudence and discretion.

26. The study of chemistry is also supposed to give a wrong turn to the mind; and set the brain at work upon impracticable schemes and projects: and in truth, there have been many wild chemical projectors. But this objection does not perhaps lie more against chemistry, than mathematics, divinity, and some other noble and rational studies, which have likewise made the head giddy: so that the fault is rather in the men than the study. Whence a hot or crazy brain should never be directed to chemistry; which of all things requires solidity; and is ever practised to best advantage, the more of plain natural sense and sound philosophy is employ'd in it. Nor do the ravings and reveries of some sanguine chemists about their elixir reflect upon the art, any more than many other dreams about the perpetual motion do upon the useful doctrine of mechanics.

27. But tho' the head may remain sound, there are still other inconveniences into which generous tempers, and public spirits are easily betray'd; upon making a little acquisition in chemistry. When a few processes have opened the mind, and given a prospect of a great and general good to be procured by them, 'tis almost natural for mankind to form thoughts of extending the benefit, and reducing experiments to works. The world is so much obliged to this enthusiastic kind of spirit, that perhaps it ought not to be curb'd, otherwise than by the difficulties and discouragements it naturally meets with in the execution of large designs. 'Tis often an easy matter in chemistry, from single experiments to form schemes of gainful business; but it often requires thought, skill, and more than ordinary abilities to erect a promising operation into a profitable trade. Nor does the great obstacle to such an advancement usually rest in the art of chemistry; but more immediately in the civil and moral circumstances of men: which are much more difficult to be seen into and directed than a chemical process; especially by those who know but little of the turns, the tempers and passions of mankind. And indeed a large share of sagacity and caution is requisite to prevent mischievous effects upon a man's private fortune; from the imprudent exercise, or rash application of chemistry; the danger in this case being seldom seen till 'tis felt. And against this evil, an extensive knowledge, sagacity, good sense, and a dispassionate view of things, are the only preservatives.

A habit of experimenting to be acquired.

28. The business of experimenting in chemistry, or conducting the various processes thereof to advantage, is an easy task, compared with the former; as depending entirely upon the acquisition of a habit for this kind of manual operation: which is the common case of artizans or handycraftsmen, who are not born to adroitness and dexterity of the hand; but form it by time and application. A young operator must not expect to go through chemical processes in the same perfection as a veteran; who might himself be no less soiled at a new operation. It would perhaps exceed the skill of a good chemist to cast a piece of ordnance, or make a sword-blade; tho' these are operations not very foreign to his ordinary employment.

employment. But a beginning must be made; and perfection will come by degrees. In case of any failure, the cause should be diligently inquired into; and the remedy found and apply'd. Thus for example, suppose a young chemist, attempting to make the common pocket-scoop, should prepare a fine solution of animal flesh, and proceed to boil it, in a common vessel, over a common fire, to its due consistence; he would find, before the operation was ended, that contrary to expectation, his scoop turn'd black, nauseous and empyreumatic. Upon inquiring into the cause hereof, he will discover that his fire was too strong, or applied too near his matter, so as to scorch or burn it like a coal. This may put him upon applying the fire to another parcel of the subject, thro' a certain medium, which will not allow it to have the same effect: and thus he is directed to the *Balneum Mariæ*; where the thing will succeed to his wish. And the like method of reasoning, casting about, and inventing, should be used in all such failures; whereby, at length, the best ways of operating will be found, and the habit of preparing commodities in their utmost perfection procured.

29. In general, chemical operations require a length of time, and a good deal of patience; to which the chemist must, by all means, inure himself. To hasten an operation in many cases is to destroy the end proposed to be answer'd by it. Thus in the rectification of brandies, our ordinary distillers sometimes make their goods, as they call them, worse than the malt-spirit they pretend to rectify; merely thro' haste and inadvertence.

30. Upon the whole, the practice of chemistry requires nothing more than common care, conduct, and good sense, to direct each process suitably to the nature of the subject, and the intention of the operator.

S E C T. II.

Description of the Furnace, its apparatus and subjects of operation.

1. **A** Principal obstacle to the general exercise of chemistry, being the difficulty of procuring proper furnaces, vessels, utensils and materials for the purpose; a portable laboratory, ready fitted for business, is here delineated.

2. The contrivance is such, that not only courses of chemical experiments and operations may be perform'd by its means; but commodities be prepared, in a sufficient quantity to supply the demands of a family and friends.

3. A thing of this kind was first attempted by that excellent chemist *Johan. Joach. Becher*; to whose labours we with pleasure acknowledge ourselves indebted.

4. The laboratory consists of three parts; viz. a furnace, an apparatus, and a *materia chemica*.

The furnace.

5. The furnace is general, or fitted to perform every operation of chemistry, for private use; or even a little circle of business. It has four principal parts, which we call by the names of the cover, the ring, the body, and the foot; all of them distinguishable at sight*.

* See plate I.
II.

6. The general office and use of the cover is to check, suppress and throw back the heat and flame, or prevent the fewel from spending itself too fast; as it otherwise would do, with little effect in many operations. For the action of fire being not momentary, but successive, the more it is kept in, and directed upon the subject, the greater its effect, or the more thriftily employ'd. In order to increase the draught, and squeeze the air more forcibly thro' the body of the fewel, there is a moveable chimney†, that may occasionally be fix'd to the orifice, left for that and other purposes, in the top of this cover‖.

† See plate I.
V. VII.
‖ See plate I.
II. V. VII.

7. The ring is the seat of numerous operations; the subject to be acted upon by the fire being frequently lodged therein: and in other cases it helps to enlarge the furnace; and render it capable of operations which it could not otherwise perform*.

* See plate I.
II. IV. VIII.

8. The body serves to contain the fewel, and is the common seat of the fire. In many cases of fusion, as in running metals from their ore, it performs, at the same time, the office of a crucible; and contains the subject, mix'd along with the fewel, after the manner practised in the smelting-houses†.

† See plate I.
II. III. &c.
‖ See plate II.
&c.

9. To this body belong three several grates‖, that may be placed at different heights therein, according to the nature of the operation, and the distance required between the subject and the fire.

10. And lastly, the foot, whereof are two kinds, is not only of use in supporting the other parts; but also in receiving the ashes of the fewel, and the melted matters, that by the fire are made to flow, and run down into it: and thus performing the office of a receiver, 'tis of singular use in collecting and preserving substances that might otherwise be spilt or lost*.

* See plate I.
II. III.
Its appurtenances.

11. The more immediate appurtenances of this furnace are fewel and bellows. The fewel may be charcoal; or, as there is a contrivance for a vent or flew in the body of the furnace, common sea-coal may be employ'd, and the smoke directed up the chimney of the room, where the furnace is to stand. Its structure also is well fitted for a lamp; which in many cases, as particularly some curious digestions and calcinations, is highly convenient. And by this means also, may the operations which would otherwise require the athanor, or a long continued uniform heat, be elegantly performed.

Its states.

12. It would be tedious to shew how all the numerous operations of chemistry are performable by means of this furnace; it may suffice, at present, to consider the general states or conditions into which the instrument may be put for the principal of them: whence its usefulness will appear to be uncommonly extensive.

For fusion.

13. The simplest state of this furnace is a combination of two parts; the body and the foot; which thus fit it for fusion, by the naked fire; where the matter to be melted is mix'd among the fewel, as in running the ores of lead,

lead, tin, or iron, for instance: which may thus, in the quantity of many pounds, be clearly separated from their dross, and purged for use, as exactly as at the mine-works, or smelting-huts; either with the assistance of bellows, or without, as the nature of the ore requires*.

* See plate III.

14. By barely placing the middle grate in the body, or trunk, the instrument becomes a melting furnace for a crucible; wherein all the operations that require a fire of fusion, animated either by the air or bellows, are performable, with such advantages as cannot be had in the common wind or blast furnaces, usually employ'd for this purpose.

15. When only the body of the furnace, with its middle grate, is set upon the foot, it answers all the ends of the common shop-furnace of the apothecary; for decoction, inspissation, extraction, &c. and the purposes of a naked fire, for certain distillations, sublimations and the like, which require so strong a heat. It may, moreover, be readily converted into a *Balneum Mariae*, an ash-heat, a sand-heat, or a still stronger for digestion, distillation, and sublimation, by barely setting upon it a pan of water, ashes, sand, or iron filings†. And thus, several operations, requiring the same kind of heat may be commodiously carried on at the same time.

Digestion,
distillation,
&c.

† See plate V.
VII.

16. If, instead of a common pan, the ring, furnish'd with its set of pots, be set upon the body, with its grate, you have a furnace fitted for distillation in *capella vacua*, as it is called; where the retorts are contain'd in the cavity of the pots, and lock'd down therein, without any visible medium between. By which means many operations may be perform'd, in the distillation and separation of bodies, that could not be work'd upon to so much advantage in any other method. And thus, in particular, may the rectification of the strongest mineral acids be expeditiously perform'd, and with little expence.

|| See plate
VII.

17. An iron pan, placed in the room of the ring, just mention'd, makes a calcining furnace; where ores may be roasted; or antimony, lead and other metalline matters commodiously calcined or reduced to ashes*.

Calcination.

* See plate V.

18. The lowest grate being used, either a cold still or a hot one, as it is call'd, may be put into the body, and work'd as in the common manner; with its proper head and refrigeratory. And thus may cordial waters be readily made, spirits rectified, essential oils distilled, &c.†.

† See plate VI.

19. The application of the cover to the hollow ring, and sometimes to the body without the ring, makes a proper reverberatory furnace; for cæmentation, cupellation, the assaying of ores, and distilling by a fire of suppression, as it is call'd; that is, where fire is placed above as well as below the vessel.

Reverbera-
tion, &c.

|| See plate IV.

20. A furnace of this nature has numerous advantages, not only over the common chemical furnaces in use, but even over those of the most celebrated structure and contrivance; whether of *Glauber*, *Vigani*, or other eminent chemists and mechanics; as usually answering particular ends, as well as general ones, better than other furnaces made for one sole end. Thus it is better fitted for the various uses of *Glauber's* philosophical furnaces, and the higher operations of metallurgical chemistry, than those invented by *Glauber* for these very purposes. For example, to obtain a pure spirit of salt in plenty, *Glauber*

Advantages
of the furnace.

Its numerous
uses.

Glauber

Description of the FURNACE,

Glauber orders the salt to be thrown upon the fire; and has contrivances to catch the rising vapour: but this is a tedious way, and turns to very little account, in practice. Nor is the matter much improved by quenching the coals in a brine of sea-salt, and burning them for their fume: but all that can be expected in this affair may be had commodiously from the present furnace; where the fire being animated with bellows, causes the fuel to burn free and yield the spirit much quicker; whilst the fuel is thrown in at the door of the furnace, without any trouble or disturbance to the operation: and thus the spirit is obtain'd as pure as this process will afford it*. And the same is to be understood of the metalline sublimations, incinerations, cæmentations, &c. of *Geber*, *Hollandus*, and those vulgarly call'd the adepts.

* See plate
VIII.

21. But there are, besides these, a great number of still more curious, and philosophical experiments, that either cannot at all, or not so justly be perform'd in a furnace of a different structure; or with so great dispatch and other conveniencies: as will be manifest upon a proper use and thorough acquaintance with the instrument.

22. In the mean time, it may be observed, that this furnace is fitted for enamelling, the making of pastes, staining of glass, the preparing of artificial gems, and performing abundance of other mechanical and philosophical experiments. It is also of such a nature, that any artizan, who requires the use of fire, may employ it in his business; as others may for the offices of a kitchen, and the common occasions of a stove; as for warming a study in cold weather, heating a vault, or the making stove-rooms, as in *Germany* and *Holland*.

23. And besides those already mention'd, there are many other particular applications of the several parts of the furnace, which are left to be discovered occasionally by such as shall use it. Thus, for example, if any one should desire a furnace to distil *per descensum*, as it is called; the cover of this furnace affords an opportunity for that purpose; being barely inverted into the foot, as may be seen in the figure †.

† See plate
VIII.

The furnace
how to be
made, and
lined.

‡ See plate I.
II.

24. The outer case of this furnace is best made of plated iron, form'd in separate pieces, of the figures express'd in the plates ‡; and of such a size as the operator shall choose; observing the same proportion betwixt the parts as the sculptures exhibit. The inner sides of all the parts are to be lined, the thickness of an inch, at least, with a proper luting, carefully laid on, and gently dried; remembering to fill up the cracks, if any happen in the drying, with more of the same luting. The following is a proper luting for the purpose. Take a bushel of *Windsor-loam*, four quarts of brick-dust, two quarts of powder'd green glass, two quarts of iron-filings, four hand-fuls of cow-hair, and eight hand-fuls of horse-dung: beat them all well together, with a sufficient quantity of bullock's-blood, so as to make an uniform paste thereof.

The apparatus
of the labora-
tory.

25. The apparatus of a laboratory should be so suited to the performance of all chemical operations, as that nothing, which is not readily procurable, may be wanting when it comes to be required in business. The following is calculated for the general uses of the portable furnace; and will serve in all ordinary cases, or common courses of chemical experiments. But for extraor-
dinary

dinary purposes it must be farther improved or enlarged at discretion, according to the particular exigencies and views of the operator.

26. All the chemical apparatus may be divided into remote and immediate; or such as is preparatory to the operations, and such as is actually employ'd therein. The remote apparatus of our portable furnace consists of several particulars. And first, as every chemical operation is to be perform'd in an exact, or geometrical, manner, good scales and weights are of absolute necessity, for determining the quantity of the subject employ'd; weight being the true index of the quantity of matter in bodies. But in common cases, or where water, and other liquors of nearly the same specific gravity with that, are employ'd, it shortens the work considerably to go by measure; which, in water nearly corresponds to weight: a pint of common water weighing a pound. Hence a set of measures are very commodious in chemical operations. But they must be used with discretion; and never be trusted in curious cases, or where the utmost exactness is required. A pint of quicksilver weighs about fourteen pounds; and a pint of spirit of wine falls short of a pound.

27. Again, as many solid substances require to be reduced into small parts, before they can become proper subjects of chemical operations, there will be a necessity for mortars, sieves, rasps, files, hammers, sheers, and forceps.

28. Next to these come the instruments used in the management of the fire; such as shovels, hooks, tongs and blow-pipes. And for charging the vessels with the subject-matters of the operations, we require hollow-shells, horns, tin-plates, brushes, hares-feet, spoons, spatulas, and rounds to set certain glasses on: and for emptying the productions, hooked-tongs, cones, ingots, basons, funnels, and store-glasses, furnish'd with common corks, wax-corks, or glass-stopples, to be tied down with bladder and leather.

29. In the last place come the instruments for making certain utensils, as cores for muffles; moulds for tests, crucibles and melting-pots; and iron-rings for cutting glasses, and the necks of retorts.

30. The more immediate apparatus, or that directly employ'd in the operations themselves, are vessels containing the subjects to be wrought upon; as particularly glass-eggs and bodies for digestion; retorts and receivers for distillation; blind-heads, for bodies, in sublimation; stone-pans and cut glasses for evaporation; peculiar spout-receivers and glasses for separation; strainers for percolation; paper for filtration; muffles and tests for cupellation; crucibles for melting; pots for cementing; and lutings to close the junctures of the vessels. A compleat set of these several utensils make the apparatus of the portable furnace, and fit it for all the usual operations of chemistry.

31. The *materia chemica*, that is, the subjects to be work'd upon, or immediately and materially employ'd in chemical operations, is the next thing to be consider'd. This is a large field, and comprehends all the natural bodies of our globe; which are all subject-matters of chemistry. We can therefore only select for a portable laboratory, such of them as are most necessary, or difficult, to be procur'd, especially at any distance from large trading cities, and populous towns. This collection being distributed into pro-

Description of the FURNACE,

per classes, will come into a small compass; and may be commodiously carried, either by Land or Sea, along with the furnace and its utensils.

32. We shall attempt to range it under the three heads of vegetable, animal and mineral substances; and to fit it for general use. But if any one desires to enlarge or improve his collection, he might do well to observe some certain order, or proceed in the manner pointed out by *Becher*, in his subterranean physics (*f*); as what was long practised by himself to advantage.

33. *Becher* endeavours to range all chemical subjects under eight general classes; viz. metals, minerals, decompounds, salts, gums, earths, stones, spirits and oils.

(1.) The class of metals contains gold, silver, copper, iron, tin, and lead, both in their natural and artificial state; that is, both in their ores, and as they are separated and purified for human uses. Add to these the artificial, compound or mix'd metals; as pewter, bell-metal, brass, gun-metal, pin-metal, *Bath-metal*, *Wells-metal*, princes-metal, *London-metal*, white copper, white gold, yellow silver, &c.

(2.) Under minerals are included antimony, bismuth, zink, marcasite, cobalt, zaffera, manganese, arsenic, orpiment, realgar, virgin-mercury, native cinnabar, sulphur, &c. and these both pure and in their natural mine.

(3.) The decompounds of minerals include *aurum fulminans*, *luna cornua*, the calces of gold and silver, ultramarine, distill'd verdigrease, burnt copper, putty or calcin'd tin, sugar of lead, cadmia, tutty, black-lead, red-lead, litharge, white-lead, glafs of lead, simple and martial regulus of antimony, glafs, cinnabar, &c. the preparations of quick-silver, as artificial cinnabar, mercury-sublimate, precipitate, &c. And in the same manner may the decompounds of vegetable and animal substances be commodiously ranged.

(4.) The class of salts takes in sea-salt, nitre, vitriol, alum, borax, tartar, sugar, soda, pot-ash, and the compound saline fluxes for stubborn ores. Add to these the tribe of artificial salts, as *tartarum vitriolatum*, fix'd nitre, soluble tartar, *terra foliata tartari*, *nitrum nitratum*, sal-ammoniac, *Epsom-salt*, volatile salts, &c.

(5.) Under gums are ranked pitch, rosin, turpentine, wax, camphire, amber, pit-coal, jet, bitumens, balsams, and inspissated juices.

(6.) Earths take in ores, wash'd ores, sluds, calces of metals, lime, plaster, gypsum, chalk, boles, shells, sands, and all those commonly called earths, whether calcarious or vitrescible.

(7.) Stones include flints, pebbles, quarry-stone, crystal, talcs, the vulgar stones, and all the gems, from the diamond to the crystal and *fluores metallici*.

(8.) Lastly, under spirits and oils come *aqua fortis*, *aqua regia*, oil of vitriol, spirit of salt, spirit of nitre, spirit of sulphur, spirit of alum, spirit of vinegar, spirit of wine, spirit of urine, spirit of tartar, spirit of turpentine, oil of tartar *per deliquium*, &c. essential vegetable oils, as of nutmeg, cinnamon, &c. express'd vegetable oils, as of linseed, olives, almonds, &c. the compound oils, as butter of antimony, unguents, artificial balsams, &c.

34. And in this manner *Becher* advises the young operator to procure for himself an alphabet of nature, that is, a suitable collection of the *materialia chemica*; and to proceed regularly with it, as he would do in learning to read, by composing first syllables, then words, and lastly discourses out of his alphabet; viz. by forming these various bodies into mixts, compounds, and decomounds.

And the laboratory set in order.

35. But to avoid miscarriages, and prevent being impos'd upon, he farther directs an acquaintance to be cultivated with the productions of nature in their crude state, or peculiar places of growth; where being first view'd and examined, before they are gather'd or dug up, an exact knowledge of them may be procured. For want of this qualification, men, otherwise of great sagacity, have err'd in their operations, by using a wrong, an adulterated or imperfect subject instead of the true; whence numberless complaints of failure and uncertain success in the business of chemical experiments. For, as it is a maxim in the law, that every circumstance affects and alters the case; so a mistake in the least circumstance; as to time, order, or the genuineness of the subject, may affect and alter a whole chemical operation (g).

36. To this he adds another caution, as to the making a prudent and sufficiently copious collection; which being always ready at hand, may prevent sending to the druggist at every turn; where perhaps the things demanded are either not to be had, or at best not without sophistication: whence many processes intended, have been obstructed, entirely prevented, or never brought to a trial.

37. But when the alphabet of nature, like the letter in a printing-house, is distributed and lodged in its proper cells, it may readily be drawn out for use, as occasion requires. And so much as a good collection of this kind facilitates the practice of chemistry, and renders it pleasurable; so much is it render'd irksome and disgustful by the want thereof. *Becher* ingenuously declares the satisfaction he receiv'd from the use of a well-appointed laboratory, in the following words. " 'Tis impossible to express with how little expence, and trouble, yet to what pleasure and profit, numerous experiments, tho' of the most difficult kind, may be made, when the operator has all his matters ready about him. I have sometimes gone through fifty different experiments in a day: and even, whilst I am writing, if any difficulty, requiring an experiment, arises, I immediately get up, and make it; my materials for the purpose standing at my elbow, whilst I sit at my desk: so that 'tis as agreeable and easy for me to perform an operation with the furnace, as to describe one with the quill (b)." And this end it is hoped may be answer'd, by means of the portable laboratory here described.

(g) See *Becher's Physic. subterranea*. p. 189.

(b) *Ib.* 190.

S E C T. III.

*Directions for the application of the Portable Laboratory to the improvement of Chemistry.**The manner of using the laboratory.*

1. **T**HE laboratory being procured and set in order, we come, in the last place, to direct the manner of using it. And this view will lead us to sketch out some particular methods for extending and improving chemistry itself; or representing it as an art, beyond expectation, suited to the entertainment of gentlemen, philosophers, scholars and persons of employ.

2. But all at present proposed is barely to shew the paths that lead to the immense regions of chemical knowledge; without pretending to conduct the reader thro' them, any farther than by pointing to some few of the principal guides that may be safely follow'd in this pursuit.

3. Those who are not yet informed in the common chemical processes, would do well to consult the learned *Boerhaave's* new method of chemistry; which in a plain, familiar manner, delivers an instructive and useful course of operations; all of them commodiously performable upon the portable furnace. And such a course appears to be a suitable introduction to the sublimer chemistry of *Boyle, Becker, Homberg, and Stahl*; and a good foundation for its farther advancement.

For the improvement of philosophy and arts.

4. Whoever would proceed farther, may direct his chemistry to the improvement of philosophy, arts, sciences, trade, and commerce: for the promoting of which end, we here offer a few schemes of courses, which, with numerous others, are also performable upon this portable furnace.

I.

Scheme for a course of general Chemistry: or an Introduction to the several branches of chemical knowledge.

I.

*In the way of separation.**Analysis in general.*

1. **T**HE common methods of analysing vegetable, animal, and mineral substances; to shew the matters into which they are separable by the artificial application of fire, both in their natural state, and after they have been alter'd by fermentation, putrefaction, or corruption.

Hence an explanation of the chemical principles; and a notion of the structure of matter; with its uses in natural philosophy, and arts.

The best assistance in this affair seems derivable from Mr. Boyle's Sceptical Chemist, Becher's Subterranean Physics, M. Homberg's Essays upon the Principles, the numerous analyses of the Royal Academy of Sciences at Paris; and the result of their doctrine, improved by M. Homberg.

(1.)

(1.) Vegetable Subjects.

II. The manner of procuring the waters and essential oils of vegetables, *Common distillation*, in perfection; or the history of distillation *per vesicam*.

(2.) The method of procuring distill'd waters, brandies, and spirits.

(3.) The history of chemical oils; and their uses to the perfumer, the apothecary and private persons.

The foundations for this subject seem well laid by Dr. Boerhaave, in his New Method of Chemistry; and Dr. Hoffman in his Observationes Physico-chemicæ. There are also some occasional papers relating to it in the Memoirs of the Royal Academy; particularly by M. Homberg, and M. Geoffroy.

III. The simple solutions, tinctures, infusions, decoctions, robs, laques, *Simple tinctures, infusions, &c.* and extracts of vegetables; for the uses of brewing, the art of dying, the art of painting, and the service of a family. Whence an entrance is made into the grand doctrine of menstruums, solution, extraction, and simple mixture.

Most of the common chemical authors have treated these processes, but without shewing the extensive uses thereof; as having chiefly confined themselves to pharmaceutical views. Among the principal to be recommended upon this head, are Glauber, Boyle, Becher, Kunckel, Le Mort, Homberg, Hoffman, and Boerhaave.

IV. The dry distillation or sublimation of vegetables; whence the perfect *Dry distillation, or sublimation* manner of refining camphire, and an experimental inquiry whether essential oils are convertible into camphire, and camphire into essential oils: with the uses of this discovery to physicians, apothecaries, druggists, and chemists.

This subject has been little touched by authors, and at present lies obscured in uncertainty; the dispute about the nature, production, and refinement of camphire remaining unsettled: as to which point, le Febure, the elder Lemery, and some late papers in the Philosophical Transactions may be consulted, and compared with the opinions of Mr. Boyle, Boerhaave, Homberg, and other members of the Royal Academy, relating to this affair.

V. The common processes of malting all vegetable grain, for potable *Malting* liquors, and corn-spirits. Whence an explanation of the nature of seminal vegetation; and an introduction to the art of brewing.

Boerhaave in his New Method of Chemistry has given an introduction to these processes; but they have otherwise been little considered by philosophers or chemists. There are however some papers relating hereto in the Philosophical Transactions, that well deserve to be consulted.

VI. The methods of fermenting malted grain, and vegetable juices, into *Fermenting* drinks, wines, and vinegars; with the art of procuring and refining essential salts and tartar.

Hence a rational history of vinous and acetous fermentation; the diseases of wines, and their cures.

Boerhaave has open'd this subject, in his New Method of Chemistry; but Stahl, in a peculiar treatise, has carried it farther, with a view

to philosophy and practice. Some hints relating to it may likewise be found in Glauber, Mr. Boyle, the Philosophical Transactions, the German Ephemerides, Mr. Evelyn, the Vinetum Britannicum, Dr. Merret, &c.

*The making
of sugar.*

VII. The processes for reducing vegetable juices to sugars; by expression, decoction, clarification, graining, claying, and crystallization.

For directions in the several processes of this art, see Pifo's Histor. Ind. Angelus Sala in his Saccharologia, Dr. Slare on Sugars, and Sir Hans Sloane's Natural History of Jamaica. Add to these, some papers in the Philosophical Transactions.

*The making
of nitre, or
salt-petre.*

VIII. The method of procuring nitre from vegetables, &c. and purifying it for gunpowder, and other uses.

To this purpose see Glauber, Clarke, and Stahl on nitre; and compare them with the discourse of the younger Lemery upon the origin of this salt.

*The making
of volatile
salts, and sal-
ammoniac.*

IX. The method of procuring volatile salt from vegetables, for various uses, and fit to compose sal-ammoniac, for the purposes of dyers, braziers, apothecaries, and chemists.

With this view, consult the extraordinary paper of Dr. Cox upon the subject of volatile salts, in the Philosophical Transactions; Boerhaave's history of vegetable putrefaction, and his account of sal-ammoniac; and compare them with the papers of Messieurs Lemery and Geoffroy upon the manner of preparing this salt in the Levant, and imitating it in other countries, as well as nitre.

*The procuring
of wax, tar,
pitch, rosin,
&c.*

X. The method of treating vegetables for their wax, honey, gums, tar, pitch, turpentine, oil, rosin, and colophony.

Some accounts to this purpose are met with in the writers of travels and natural history; but the foundation of the thing may be seen in Boerhaave's Chemistry, Pomet, and Lemery's History of Drugs, or rather among the writers of natural history.

*The making
of charcoal.*

XI. The method of charring vegetables for fuel, so as to burn without smoke; and to be of use for the drying of malt, or other curious, chemical, and oeconomical purposes.

Glauber, Mr. Boyle, Mr. Evelyn, and the Philosophical Transactions, contain some particulars to this purpose.

*The making
of pot-ash.*

XII. The art of reducing vegetables to pot-ash, for the service of the soap-maker, fuller, scourer, dyer, glass-man, chemist, apothecary, &c.

Glauber, in his Prosperity of Germany, and elsewhere, has some useful observations relating to this subject; which is also considered by several of our naturalists: but the chemical foundation of the whole may be readily learn'd from Boerhaave, or other good writers of general courses.

(2.) *Animal Subjects.*

*The animal
principles.*

XIII. The common resolution of animal substances into their principles, pure and mix'd, for the uses of medicine and various arts.

See Boyle's History of Human Blood, his Sceptical Chemist, &c. Dr. Cox's papers in the Philosophical Transactions, Boerhaave's processes upon animals, and Stahl's Philosophical Principles of Chemistry.

XIV. The manner of separating the more medicinal parts of animals, in *Gallies*, the way of simple solution, tincture, gelly, &c. for the uses of the apothecary, &c.

This subject has been little treated in a philosophical view; but receives some light from Boerhaave's Processes upon Animals, Mr. Boyle's Experiments on human blood, the Use of Papin's Digestor, and the common pharmaceutical chemistry.

XV. The manner of separating and purifying the fat of animals, for the uses of the soap-boiler, chandler, clothier, &c. *Preparing fats.*

The difficulty here lies in taking off the nidorous odour of coarse, animal oils, or fats; and rendering them fit for the finer uses, as in the making of Sperma Ceti from train-oil, &c. And in this affair, the methods delivered by many chemical authors, for rectifying and purifying some empyreumatic oils, may be of service: but more commodious methods for practice are still required.

XVI. The method of separating phosphorus from animal subjects; and reducing them to a kind of lamp-black, ashes and earth, for the uses of painting, dying, printing, colouring, assaying, &c. *Phosphorus and virgin earth.*

The affair of the animal phosphorus is deliver'd by Mr. Boyle and M. Homberg; and the foot, the black, the ashes, and the earth, are touch'd upon by Boerhaave, and others.

(3.) Mineral Subjects.

XVII. The general methods of reducing mineral-juices to a dry substance; so as to come at the solid matter they contain; with a view to the art of mining, or the discovery of metalline-veins, the erection of salt-works, vitriol-works, alum-works, borax-works, &c. *The art of condensing mineral juices.*

This subject is prosecuted by George Agricola, at the close of his work de re metallica: and the view is carried farther by Mr. Boyle, Becher, Stahl, Homberg, and some other members of the Royal Society, and the Academy of Sciences.

XVIII. The manner of reducing solid mineral salts to fluid acid spirits, by separation or distillation; for the numerous uses of dying, etching, assaying, the preparation of menstrua for metals, and many other subjects. *Preparation of acid mineral menstrua.*

The processes for this purpose are deliver'd by all writers of chemical courses; but the rationale, and the just application of the productions to mechanical, philosophical, and chemical uses, are sparingly touch'd upon by them. Those who would go deeper in this affair, may consult Dr. Stahl's Principles of Chemistry, Mr. Boyle's Essay upon Nitre, and M. Homberg's Paper on Acid Spirits. Add to these, Agricola, de re metallica, and others who have wrote upon the business of assaying.

XIX. The general method of analysing solid minerals; or resolving them into flowers, sulphur, arsenic, earth and metal, or any other particular substance they may contain; with a view to philosophical mineralogy; and the vulgar art of metals; or the procuring all mineral subjects in their pure, separate, and artificial state. *Analysis of solid minerals. Those*

Those who desire to see how this business is treated at the mines, may find an entertaining account of it in George Agricola's work *de Re metallica*. There is also a good deal to the same purpose delivered up and down in the writings of Paracelsus, Helmont, Glauber, Ercker, and Mr. Boyle. But among the capital performances, in the philosophical and chemical parts of this affair, stands that of Becher, call'd his *Phyfica subterranea*, especially as it is improved by the labours of Dr. Stahl.

The design of this course has hitherto been to shew the general manner of separating from chemical subjects, whether vegetable, animal, or mineral, the distinct, similar, or homogeneous parts that enter their composition; so as to procure them simple, and fit for use. All these productions, therefore, are so many artificial things, obtain'd by a chemical reduction of natural bodies; which, as well as the artificial, may be compounded and recomposed by art, like the letters of the alphabet, into many thousands, or even millions of new and unknown bodies; all of them creatures of chemistry: which shews the great power and extent of this art.

II.

In the way of combination.

Synthesis.

Among the experiments relating to the combination of vegetables with vegetables, may come,

The uniting of vegetable oils with water, &c.

XX. The ways of combining essential oils with vegetable waters, sugars, and inflammable spirits, for various uses.

See Boerhaave's *New Method*, and Stahl's *Philosophical Principles of Chemistry*.

Making of soaps.

XXI. The methods of combining vegetable oils and vegetable salts into soaps, and the *sales volatiles oleosi*; for the purposes of medicine, a family, and several trades.

Consult, upon this head, Starkey on the soap of tartar, Boerhaave's *Chemistry*, and Homberg's paper describing a particular soap for taking away freckles.

Making of neutral salts.

XXII. The ways of combining fix'd and volatile vegetable salts with vegetable acids; so as to make artificial neutral salts, of singular virtues and uses.

Many curious particulars relating to this purpose, are found in Mr. Boyle's *Philosophical Works*, the French *Memoirs*, and the *Philosophical Transactions*.

Spirit of wine united with vegetable acids, &c.

XXIII. The method of combining inflammable spirits with vegetable acids, and with rosins, for medicinal and mechanical uses; shewn in the art of wines, brandies, and the making of compound varnishes.

This subject receives some light from the common processes of chemists, for dulcifying acid spirits; and making the ordinary tinctures: but its more extensive use must be derived from the philosophical chemists, as Boyle, Homberg, and those who describe the arts of distillation and japanning.

Experiments

Experiments relating to the combination of vegetable with animal subjects.

XXIV. The method of combining animal or vegetable salts, and resins, *Alcohol with* with alcohol, brandy, wine, vinegar, or water; for the uses of pharmacy *salts.* and other arts.

The common chemical books are full of processes to this purpose; as Le Febure, Le Mort, Lemery, Wilson, Barchusen, and Boerhaave.

XXV. The ways of combining fix'd salt and animal fat into soap; blood *Animal fat* and fix'd salt into a blue pigment; animal flesh and vegetable balsams into *with fix'd* mummy; with other particulars of this nature. *salt, &c.*

See Boerhaave's chemistry, and the Philosophical Transactions.

Experiments relating to the combination of animal with mineral subjects.

XXVI. The method of combining various minerals with animal oils, *Plasters, and* and fats, into unguents, plasters, and paints. *paints.*

The common dispensatories have the processes for this purpose; but the philosophy of them must be derived from chemical authors; as particularly Boyle, Becher, and Boerhaave.

XXVII. The method of re-compounding or restoring the calces of metals, by the addition of a little animal, or vegetable fat: whence an experimental inquiry into the phlogistic principle of Dr. Stahl; with its use in the business and philosophy of metals. *Reduction of metals from their calces.*

XXVIII. The way of rendering alkaline animal salts neutral, or turning them into sal-ammoniac, by combining them with the spirit of sea-salt. *Making of sal-ammoniac.*

See the dispute betwixt Geoffroy and Lemery, about the preparation of sal-ammoniac, in the French Memoirs.

Experiments relating to the combination of vegetable with mineral subjects.

XXIX. The ways of combining vegetable salts with mineral sulphurs; whence the separation of metals from their ores, and the production of numerous kinds of slags or scoræ; with their chemical and philosophical uses. *Salts united with sulphurs.*

Upon this head consult Agricola, de Re metallica, Ercker, and other chemical writers upon mines and minerals: Boerhaave in the history of antimony; and Stahl in his several pieces of metallurgical chemistry.

XXX. The ways of combining fix'd vegetable salts with mineral earths; whence the foundation of the art of glass, and the art of metals; with the philosophy of vitrification and metallization. *Vegetable salts with mineral earths.*

See upon this head Boyle of gems; Neri's art of glass, with Kunckel's notes; and Stahl's pieces of metallurgical chemistry; as also his comment upon Becher's Subterranean Physics.

XXXI. The ways of combining metalline matters with vegetable liquors; whence many medicinal tinctures, or solutions, of metals, and the whole business of inks. *Vegetable liquors with metals.*

SCHEME for a Course

See Boerhaave's *Chemistry*; and Homberg's *Experiments upon this subject*, apud du Hamel, in *Hist. Acad. Regal. Parisiens.*

Experiments relating to the combination of mineral with mineral subjects.

*Mineral acids
with metallic
matters.*

XXXII. The ways of combining the mineral acids with metallic matters; whence the numerous tinctures, solutions, sublimates, præcipitates, calces, &c. of gold, silver, mercury, lead, iron, &c. with their extensive uses.

All the chemical authors have more or less treated this copious subject.

*Minerals
with metals.*

XXXIII. The general ways of combining minerals with metals; as sulphur with iron, arsenic with gold or silver, calamy with copper, &c. whence various discoveries as to the philosophy of metals; and the natural composition of ores and mineral substances, which are thus imitated by art.

See upon this head Becher, and Stahl, in particular.

*Metal with
metal.*

XXXIV. The art of combining metal with metal, in the way of electrum; or making the mix'd metals.

Much light is given to the philosophical part of this business by Mr. Boyle, and M. Homberg; tho' the practical part of it has generally fallen into mechanical hands. But Agricola, Ercker, Glauber, Becher, and Stahl may be consulted upon it.

Experiments relating to the combinations of subjects of the three kingdoms promiscuously.

*Promiscuous
mixtures.*

XXXV. The combination of nitre, coal and sulphur into gunpowder; fix'd vegetable salt, sand and metal into glass of all colours; nitre, salt of tartar, and sulphur into the *pulvis fulminans*; sal-ammoniac, and quick-lime into a certain phosphorus; alum, wheat-flower, or other vegetable or animal substances, into the common black phosphorus: with numerous examples of the same general nature.

And in this view all the original chemical authors should be consulted; not omitting even those called the adept, from Hollandus, Valentine, Lully, Friar Bacon, Paracelsus, Helmont, &c. down to Boyle, Philaetha, Becher, Homberg, and Stahl. Add to these, the authors who have wrote upon particular trades; requiring the joint assistance of subjects from all the three kingdoms.

*New men-
struums from
mixture. I*

XXXVI. Experimental attempts to direct the farther combination of subjects; and productions, of the three different kingdoms; with a view to discover new solvents, or mixtures, for the purposes of medicine, the mechanic arts, and the farther uses of life.

Little to this purpose has hitherto been done by any single author; and indeed a proper work of the kind requires the joint labour of many. But Mr. Boyle, and Boerhaave have open'd the affair; and certain members of the Royal Academy and Royal Society have pursued it. See Boyle passim, and Boerhaave's chapter of menstruums.

XXXVII.

XXXVII. Experiments relating to the recomposition of bodies, or combining their separated principles together, so as to compose the original concrete again. *Recomposition.*

See Mr. Boyle's *Experiment upon Nitre*, M. Homberg's *Essays*, and Dr. Stahl, both in his *Philosophical Principles of Chemistry*, and his *Opusculum Chymico-Physico-Medicum*.

II.

Scheme for a Course of Philosophical Chemistry; or, the application of Chemical Experiments to the improvement of Natural Knowledge.

I. **A**N experimental inquiry into the chemical nature, and internal *Chemical structure of matter.* structure of matter, in the different aggregates, or masses of animals, vegetables, and minerals; compared with the experiments and observations of Boyle, Becher, Hook, Newton, and some other members of the royal society, and royal academy of sciences.

II. An experimental view of the various states and forms into which matter is reducible by chemistry; as to fluidity and solidity, exhalations, vapours, heat, cold, gravity, density, hardness, softness, colour, consistence, odour, &c. *Various schemes or forms of matter.*

Under this head Mr. Boyle has perform'd something considerable upon the Lord Bacon's Plan; and seems, in a manner, to have engross'd the subject.

III. A view of the different relations, vulgarly call'd sympathies and antipathies, or attractions and repulsions, observ'd betwixt different bodies; with the uses of this doctrine in philosophy, and chemistry. *Secret relations of the different schemes of body.*

See Boyle, Hook, Homberg, Newton, Stahl, and the Memoir of Geoffroy in the Works of the Royal Academy for the Year 1718.

IV. An experimental inquiry into the real principles of natural bodies; how far the fire gives a just analysis, and how far it fails therein; whence the doctrine of chemical separation and combination may be justly settled. *Principles of bodies.*

Among the principal authors to be consult'd upon this head are Bacon, Boyle, Becher, Homberg, and Stahl.

V. An experimental inquiry into the business of mixture, natural and artificial; or the best and most intimate manner of uniting solid with solid, solid with fluid, fluid with fluid, &c. according to the ends for which they are design'd. *Doctrine of mixture.*

Great light may be deriv'd in this inquiry from the Works of Mr. Boyle, Becher's Subterranean Physics, Stahl's Comment thereon, and his Paper upon Mixts, Texts and Aggregates, published in his Opusculum Chymico-Physico-Medicum, and the Observationes Hallenses.

*Explanation
of the nature
and office of
chemical operations.*

VI. A philosophical explanation, and experimental illustration of all the chemical operations, as so many means of effecting certain changes in bodies, according to certain rules, for the various purposes and intentions of the art. *Something of this kind was attempted by Dr. Friend, in his Praelectiones Chemicæ; but the view is enlarged by Boerhaave and Stahl: yet well deserves to be farther prosecuted, as it includes no inconsiderable branch of natural philosophy.*

Chemical operations improved.

VII. An experimental attempt to improve the chemical operations; so as to render them capable of performing what could not otherwise be expected from them.

Mr. Boyle has many curious hints to this purpose; so has M. Homberg: but the thing is more fully considered by Dr. Stahl, in his comment upon Becher; and in several of his Schediasmata.

Doctrine of menstruums.

VIII. A set of experiments to unfold the useful and extensive doctrine of menstruums; or the business of adapting solvents to all kinds of bodies.

Mr. Boyle affords many improveable hints to this purpose; and Boerhaave's chapter of menstruums may serve as an introduction to the inquiry.

Nature and uses of fermentation and putrefaction.

IX. Experiments to discover the nature and uses of fermentation and putrefaction in the system of the world; as they are natural means of converting one body into another.

See Boerhaave's Chemistry, Boyle's philosophical Works, Becher in his Physica subterranea, and Sir Isaac Newton's Queries, at the end of his Opticks.

The doctrine of acid and alkali.

X. Experiments to adjust, establish, and illustrate the doctrine of acid and alkali.

See Boyle, Bohn, Homberg, Boerhaave, Stahl, and Newton's paper upon the subject, publish'd in Harris's Lexicon Technicum.

The doctrine of the four elements.

XI. A set of introductory experiments, to shew the general nature, offices, and uses of the elements in the system of the world.

This article is touch'd upon by the Lord Verulam and Mr. Boyle, reconsidered by M. Homberg, and Boerhaave; and in some particulars improv'd by Sir Isaac Newton.

The nature of fire and heat.

XII. A set of chemical experiments to unfold the nature of fire and heat, with the modus of their operation upon bodies, for the production of various effects.

A foundation for this inquiry is laid by the Lord Bacon in his Novum Organum, and improved by Mr. Boyle, M. Homberg, Bohn, Boerhaave, Lemery, and Swedenbourg.

Nature of the atmosphere.

XIII. A set of chemical experiments to discover the ingredients of the atmosphere; and account for its various effects, operations, and phenomena; with regard to bodies lodged or digested therein.

This subject has been prosecuted by Mr. Boyle; and seems brought to a little system by Boerhaave, in his chapter of air, considered as a chemical instrument.

XIV.

XIV. An experimental inquiry into the nature of water, its office and uses in the globe; the origin of hot and cold springs, the saltness of the sea, and the different kinds of mineral waters. *Nature of water.*

See Mr. Boyle, Becher, Lister, Boerhaave, Newton, Bernoulli, Stahl, and Hoffman.

XV. Experiments to shew the nature and uses of earth, considered as an element. *Nature of elementary earth.*

Among the best guides in this affair must again be reckon'd Boyle, Becher, Boerhaave, Newton and Stahl.

XVI. Attempts to imitate various phaenomena of the atmosphere; as thunder, lightning, coruscations, the *aurora borealis*, water-spouts, rain, hail, snow, &c. *Nature and imitations of meteors.*

See the paper of M. Lemery *sen.* Memoir de l'Academ. An. 1700. and compare it with the discoveries of Mr. Boyle, M. Homberg, Sir Isaac Newton, and certain papers in the Philosophical Transactions, relating to this article.

XVII. Attempts to imitate some natural phaenomena proceeding from causes within the earth; as subterranean heats, fires, fumes, eruptions, vulcanos, earthquakes, boiling waters, &c. *Subterraneous phaenomena.*

See the writings of the naturalists, particularly Dr. Woodward; and compare them with the experiments and discoveries of Mr. Boyle, Sir Isaac Newton, and Messieurs Homberg, Lemery, Geoffroy, and Dr. Hoffman.

XVIII. A chemical inquiry into the business of vegetation, animalization, and mineralization; or the growth, nourishment, natural decays and changes of vegetable, animal, and mineral bodies. *Nutrition and growth of bodies.*

See the experiments of Woodward and Homberg upon Vegetation; Digby on Nitre; Evelyn on Agriculture; Cox and Boerhaave on Putrefaction; and Boyle, Becher, and Stahl upon the origin, growth, and formation of subterraneous bodies.

XIX. Chemical experiments relating to the human body, in its natural healthy state, or the various chemical operations perform'd therein. The nature of the several animal fluids; the changes they undergo; their mixtures, separations, uses, and effects upon each other, and upon the whole, so as to maintain a healthy state. *Natural chemistry in the body.*

With this view consult Boyle, Bohn, Boerhaave, and Hoffman.

XX. Experiments relating to the nature of morbid juices, or fluids displaced, concreted, fused, or alter'd in the body; and to the causes and cures of diseases by peculiar solvents or specifics. *The morbid fluids of the body.*

Consult upon this head Mr. Boyle's discourse of specific Remedies, Boerhaave's chapter of menstruus, and certain papers in the French Memoirs, attempting to discover solvents for the stone in the bladder, &c.

XXI. Experiments to determine *a priori* the nature and medicinal virtues of mineral waters. *Mineral waters.*

See

SCHEME for a Course

See Mr. Boyle upon the subject, and compare him with Dr. Hoffman; by which means a foundation may be laid for a due prosecution of this affair.

*New powers
to be used in
chemistry.*

XXII. An attempt to introduce some new instruments into chemistry, for the more exact performance of certain operations, both in the way of separation and combination; particularly the instrumental agency of cold, and the powerful furnace of the Sun.

Upon this head consult the Lord Bacon, and Mr. Boyle; and with their discoveries compare the experiments of M. Homberg and Dr. Stahl, as to the effects of high degrees of cold and heat in chemical operations.

*The chemistry
of nature, at
large.*

XXIII. An attempt to explain the chemistry of nature, or the manner wherein the world is continually recruited in all its parts; the earth refresh'd with dew and rain; the atmosphere stored with vapours, and the seeds of vegetables; vegetables swelled with moisture, and expanded by the heat of the sun; the air furnish'd with its renovating spirit; and fire, air, earth and water conserved to repair the animal, vegetable, and mineral worlds, and preserve the divine order and harmony of material things.

This is the favourite topic of philosophers; which they usually touch successfully. But among the best authors upon the subject, we rank the Lord Bacon, Mr. Boyle, Dr. Hook, M. Homberg, Mr. Ray, Dr. Derham, Mr. Evelyn, Dr. Stahl, and Sir Isaac Newton.

III.

Scheme for a Course of Pharmaceutical Chemistry: or the Art of preparing medicines.

(I.)

An introduction to the pharmaceutical operations; shewing the instrumental efficacy of fire, air, water, and earth therein.

*Subjects suited
to fire.*

1. THE subjects suited to the instrumental efficacy of fire; viz. volatile fluids, volatile solids, inflammable, fusible, calcinable, and vitrifiable bodies.

Air.

2. Subjects suited to the instrumental efficacy of the air; viz. relenting salts, exhalable bodies, and salts disposed to crystallize.

Water.

3. Subjects suited to the instrumental efficacy of water; viz. salts, mucilages, spirits, powders, gums, and all bodies affected by the *Balneum Mariæ*.

Earth.

4. Subjects suited to the instrumental efficacy of earth; as all solid machines, engines, and vessels form'd of earthy materials. Whence a chemical explanation of trituration, aggregation, solution, coagulation, evaporation, crystallization, præcipitation, sublimation, distillation, digestion, detonation, candefaction, fusion, incineration, calcination, deliquation, regeneration, congelation, and fermentation of the various kinds, with direct relation to pharmacy.

(II.)

(II.)

The principal subjects, and general operations, to be exhibited in a course of pharmaceutical chemistry.

I. A just collection of the *materia medica*; or, (1.) A set of dry'd medicinal herbs, flowers, fruits, seeds, roots, barks, and woods. (2.) Dry'd parts of animals; or animal substances having any medicinal virtue. (3.) A set of medicinal fossils; all distributed into proper classes.

General pharmaceutical operations upon vegetables.

II. Experiments to shew how any crude, vegetable subjects, being barely cut, bruised, or reduced to powder, may have their whole substance made into species, candies, confections, conserves, cataplasms, pills, or electuaries; by distillation, into waters and essential oils, and with a scorching heat into empyreumatic oil: by decoction, in water or spirit of wine, into tinctures, essences, and extracts; and by expression, or long continued coction, into oils.

III. To shew how essential, vegetable oils and essences are form'd into elixirs, and sweet scented balsams: and how express'd, vegetable oils, boil'd with vegetable juices, gums, rosins or powders, become unguents, liniments, compound oils, or plaisters.

IV. To shew that most vegetable juices and seeds yield, by fermentation and distillation, an inflammable spirit, that becomes compounded by being drawn over from certain ingredients, or impregnated with their virtues; whence the tribe of compound or spirituous waters; the rectification of vinous spirits; and the preparation of alcohol *per se*, and tartariz'd; with various tinctures and solutions made by their means.

V. That vegetables afford salts, call'd essential and alkaline, by crystallization and incineration, of considerable use in pharmacy: and that by distillation, they yield an empyreumatic oil, an acid spirit, and a foot.

VI. To shew that all sweet vegetable juices afford wines by fermentation, and afterwards vinegar: whence medicated wines and vinegars, with numerous compound preparations, by means of these two menstrua.

VII. To shew that the same inspissated vegetable juice affords, by distillation *per se*, an acid spirit, an empyreumatic oil, a black coal, and afterwards a fix'd salt.

VIII. That tartar and wine- lees, by the retort afford an inflammable spirit, an empyreumatic oil, a volatile salt, printer's black, or a peculiar spirit, *caput mortuum*, and salt of tartar.

IX. That rosins and gums afford a fine ætherial oil, an empyreumatic oil, a little acid salt, an unctuous *caput mortuum*, or a coal that by burning falls to ashes.

General pharmaceutical operations upon animals.

X. To shew how the parts of animals are fitted for pharmaceutical preparations, in the form of powders, shavings, chips, gelly, a black coal, or a white pulverable substance produced by philosophical calcination.

Boil'd, distill-
ed and burnt.

XI. That animal substances, boil'd in water, make a gelly, size, or gliew; and by burning *in occluso*, afford a spirit, oil, volatile salt, and *caput mortuum*, or coal; which being burnt in the open air, affords ashes, containing salt, and elementary earth.

General pharmaceutical operations upon minerals, relating to pharmacy.

Mineral salts
distill'd.

XII. Experiments to shew that mineral salts are resolvable by distillation *per retortam* into acid spirits, and an earthy *caput mortuum*; and that certain sulphureous and arsenical minerals may be sublimed, and reduced into sulphur, arsenic, regulus and metal.

Metallic cal-
ces dissolv'd.

XIII. That certain mineral matters, and metalline calces, dissolve with oil, and form plaisters; that metals with acid spirits form compound salts; and that sulphurs dissolve with oil into balsams; and with alcohol into tinctures.

(III.)

The particular operations, and more necessary preparations of
pharmaceutical chemistry.

In the vegetable kingdom.

Distilled wa-
ters.

XIV. Rules for the drawing of simple and compound waters, and essential oils, to the greatest perfection; exemplified by distilling a fresh medicinal simple in *Balneo Mariæ*, without any addition of water; certain essential oils, according to the directions of Dr. *Hoffman*; and certain compound waters, according to the practice of the best distillers: with the uses to be made of the residuum in each process; and the common fraudulent practices of sophisticating, adulterating, or debasing these preparations.

Brandies.

XV. The method of distilling inflammable spirits and brandies, from wash and wines; as malt-spirit, melass-spirit, &c. and fitting, or rectifying them for pharmaceutical uses, in the form of low-wines, proof-spirit, alcohol *per se*, and tartarized spirit of wine: with the extemporaneous method of making simple and compound waters.

Tinctures
with aqueous
and spirituous
menstruums.

XVI. The best manner of preparing the medicinal infusions, tinctures, extracts, elixirs and rosins, with aqueous and spirituous menstruums. As the *vinum absinthites*, *vinum viperinum*, *vinum emeticum*, *tinctura sacra*, *laudanum liquidum*, *elixir proprietatis*, *elixir vitrioli*, *tinctura cantharidum*, *tinctura formicarum*, *castorei*, *millepedum*, *moschi*, *salis tartiri*, *terre foliatæ tartari*, &c. Extract of colocynth, aloes, jalap, senna, hermodactyls, agaric, ipecacuanha, &c. according to the experiments and observations of M. *Bouldu*, and other members of the *French academy*. Rosin of scammony, rosin of jalap, rosin of guaiacum, &c. with their sophistications and adulterations.

Vegetable
juices how
preserved.

XVII. The method of preserving vegetable juices in perfection; and of reducing them to syrups, robs, gellies, and mivas, exemplified in the more useful and difficult preparations of this class: as the syrup of violets and raspberries, the rob of elder and juniper, the *resiné of France*, &c. with the best manner
of

of making syrups by decoction, so as to secure the particular virtues of the vegetables employ'd; according to the hints of *Charas*, *Boerhaave*, and *Stahl*, with regard to the nature of sugar, or the disposition it has to imbibe oleaginous or resinous matters, like salt of tartar, and render them saponaceous.

XVIII. The methods of procuring the essential salts of vegetables, and *Essential* those term'd medicated salts, and fix'd salts; with the ways of converting *salts* the latter into neutrals, or a species of medicated salts, by means of tartar and distill'd vinegar: whence the soluble tartar, and that curious salt called *terra foliata tartari*. Add to this, the methods of neutralizing mineral acids; or recovering salts from their acid spirits, by means of fix'd, vegetable alkali.

XIX. The best methods of making the fix'd salts of vegetables for phar- *Fix'd salts,* maceutical uses, and running them *per deliquium*; particularly salt of worm- *and caustics.* wood, salt of tartar, and fix'd nitre: with an inquiry into the reasons of substituting salt of pot-ash for them; and the ways of using these salts in infusions and decoctions, so as to extract the medicinal parts of the ingredients, without impairing their virtues, or destroying their oleaginous and resinous principles by rendering them too saponaceous. Add to this, the method of making fix'd salts into caustics, for surgical uses.

XX. The method of making fix'd salts into medicinal soaps; or uniting *Medicinal* them with wax, *sperma ceti*, balsam of *Peru* and *Tolu*, balm of *Gilead*, *soaps.* balsam *Capivi*, and other fine turpentine or balsams: and this kind of preparation compared with the *Eleosacchara*.

XXI. The ways of compounding simple oils, wax, gums, balsams, and *Cerats, un-* certain metalline calces into officinal oils, unguents, cerats, and plaisters, *guents, and* exemplified in the more curious and difficult preparations of this class. *plaisters.*

(IV.)

Certain subjects of the vegetable kingdom, requiring a more particular consideration.

XXII. An attempt towards a perfect analysis of the *Peruvian bark*; with *The bark.* the method of making it into the most innocent and effectual medicine.

See the Paper of M. Charas upon this subject, in the Memoirs of the Royal Academy before its re-establishment.

XXIII. The best ways of collecting, purifying, preparing and exhibiting *Opium.* opium.

See the anonymous French Author on the Sugar-works of the Isles; Boerhaave's Chemistry, and Dr. Hoffman's Observationes Physico-Chymicæ.

XXIV. The best ways of purifying, dissolving, combining, and exhi- *Camphire.* biting of camphire.

See Hoffman's Observationes Physico-Chymicæ, Dr. Quincy's Pharmaceutical Lectures and Dispensatory, and compare them with Mr. Brown's, and Dr. Newman's Papers, upon this Subject, in the Philosophical Transactions.

SCHEME for a Course

Sugar.

XXV. A farther application of sugar to pharmaceutical uses, as a kind of dry menstruum, that grinds with balsams, gums, inspissated juices, mercury, metals, &c. into powders; which thus become soluble in water, and capable of being exhibited with great advantage.

There are some hints to this purpose in a certain anonymous French Author, who gives the History of the Sugar-works, and the Chocolate-Trade in the Isles.

In the animal kingdom.

Preparing
urinous ani-
mal substan-
ces.

XXVI. Experiments to shew the methods of preparing certain animal substances for the uses of pharmaceutical chemistry; viz. the refining or preparing of the animal fats, as the *adeps viperarum*, *axungia porcina*, *pomatium*, *sebum cervinum*, *sebum meliloti*, *butyrum Maiale*, *sperma ceti*, &c. The preparing of millepedes, cantharides, cochineal-flies, isinglass, vipers, rob of urine, dry'd blood, musk, civet, sal-ammoniac, &c.

Testaceous
bodies.

XXVII. The method of preparing testaceous, animal substances; as oyster-shells, egg-shells, pearls, crabs-eyes, crabs-claws, *Bezoar*, *Goa-stone*, *Gascoign's powder*, &c.

Horn and
bone.

XXVIII. Experiments to shew the effects of decoction and calcination in animal substances; particularly in hartshorn for gelly, and the *decoctum album*: with the pharmaceutical history of animal gellies; and the calces of animal bones.

XXIX. The methods of procuring the volatile urinous spirits, salts, and oils of animal substances; as hartshorn, blood, urine, &c. and rectifying or purifying them in the best manner, and converting the salt into sal-ammoniac for medicinal uses.

Silk, &c.

XXX. The preparations from raw-silk, vipers, and some other curious animal subjects.

Sal-ammo-
niac.

XXXI. The various preparations with sal-ammoniac; particularly volatile spirits, salts, and the *sales volatiles oleosi*, simple, compound, and extemporaneous; its acid spirit, diuretic salt, secret salt, and double menstruum, as they are called; with the general method of subliming metalline and mineral bodies by its means.

In the mineral kingdom.

Sulphur.

XXXII. Experiments to shew the manner of separating and purifying sulphur, by sublimation; and the method of making the *oleum sulphuris per campanam*, or converting almost the whole body of the sulphur into acid spirit; with so much of the discoveries of M. *Homborg*, and Dr. *Stahl*, relating to the analysis, regeneration, and production of this mineral, as tends to the service of pharmacy.

XXXIII. Experiments to shew the manner of dissolving sulphur in fix'd or volatile alkalies, alcohol, and oils; whence the several balsams and tinctures of sulphur, liver of sulphur, and lac sulphuris.

Purification
of mineral
salts.

XXXIV. The best methods of procuring and purifying mineral salts, and fitting them for pharmaceutical uses; particularly nitre, sea-salt, alum, and vitriol.

XXXV.

XXXV. The various methods of resolving mineral salts into their acid spirits, and rectifying them: or the ways of making oil of vitriol, spirit of sea-salt, spirit of alum, spirit of nitre, and dulcifying them for pharmaceutical uses. Add to these the compound acid spirits, or the *aqua fortes*, and *aqua regia*, for pharmaceutical purposes; with the methods of extracting new salts from the several residuums, for the uses of pharmacy; whence the *sedativum Hombergii*, *sal mirabile Glauberi*, a salt like the *Epsom-salt*, the *sal enixum Paracelsi*, the common *tartarus vitriolatus* of the shops, the *arcanum duplicatum*, &c.

XXXVI. Experiments to shew the methods of purifying all the metals, and metalline matters, and fitting them for pharmaceutical uses.

XXXVII. Experiments to shew the best ways of preparing the metalline tinctures, solutions and calces, with the simple and mix'd mineral acids; whence the pharmaceutical solutions, sublimates, calces, vitriols, and crocus's of iron, lead, silver, tin, copper, mercury, and gold.

XXXVIII. The pharmaceutical preparations of iron; viz. *crocus Martis Preparations astringens & aperiens*; *oleum Martis per deliquium*; *tinctura Martis aurea*; *tinctura Martis cum vino & cum aceto*; *flores ammoniaci Martiales*, &c.

XXXIX. The pharmaceutical preparations of lead; viz. *saccharum Saturni*; the calx of lead, white-lead, yellow-lead, and red-lead, balsam of lead, and plaister of lead.

XL. The pharmaceutical preparations of silver; viz. the crystals of silver, the silver pill, the precipitate and tincture of silver, the lunar caustic, and the *Luna cornua*; with their reduction to silver again. Add hereto, the solution of silver, for turning red and grey hair into black or brown.

XLI. The pharmaceutical preparations of tin. Calx of tin; amalgam of tin with mercury; salt of tin, magistery of tin, flowers of tin, sublimate of tin, smoking oil of tin, and *aurum Mosaicum*, as 'tis call'd.

XLII. The pharmaceutical preparations of copper. The solutions of copper in various saline, or acid and alkaline menstruums; whence *aqua sapphirina*, and various vitriols. The preparation of verdigrease; the spirit of verdigrease; the calx and crocus of copper; *as ustum*; and Mr. Boyle's *ens Veneris*.

XLIII. The pharmaceutical preparations of quicksilver. The general method of amalgamating metals. The solutions and crystallizations of quicksilver. The best ways of making corrosive-sublimate, *Mercurius dulcis*, calomel, red precipitate, yellow precipitate, or *turpetum minerale*, white precipitate, and the oil of mercury: with the ways of making quicksilver into *Astbiops* mineral, cinnabar, and a saccharine powder.

XLIV. The pharmaceutical preparations of gold. The solutions of gold, the amalgam of gold, *aurum fulminans*, various calces of gold: with the more successful methods of making an *aurum potable*, and sublimate of gold.

XLV. The pharmaceutical preparations of antimony. The separation of antimony into sulphur and regulus. The pure, simple, and martial regulus of antimony: with a certain way of making the *regulus Martis stellatus*. The best ways of preparing *antimonium diaphoreticum*, *nitrum antimoniatum*, *antibelliticum Poterij*, butter and oil of antimony, the *Mercurius vite*, Bezoar mineral,

SCHEME for a Course

mineral, and cinnabar of antimony. The emetic cups, perpetual pills, emetic flowers, and purging flowers of antimony; the *crocus metallorum*; and *tinctura metallorum*; the *Bezoardicum Solare, Lunare & Martiale*; the calx, sublimate, and glass of antimony.

True and false method of prescribing in pharmacy. XLVI. Experimental instances of the true and false manner of prescribing, both in officinal and extemporaneous pharmacy; with relation to efficacy and elegance.

Sophistications.

XLVII. A set of experiments to shew the more considerable adulterations, sophistications, and substitutions practised among the trading chemists, wholesale apothecaries and druggists; with the certain ways of distinguishing the *vera* from the *communis*. For example; the common sophistications of the dear essential oils, as particularly oil of cinnamon, nutmeg, cloves, spike, &c. The rich balsams, as those of *Peru, Tolu, and Gilead*, storax, galbanum, &c. The resins of jalap and scammony; salt of amber, salt of vipers, *Bezoar*, *Goa-stone*, *Gascoign's-powder* and pearl; *oleum sulphuris per campanam*, *antimonium diaphoreticum*, cinnabar native and factitious, quicksilver, &c.

The authors who have treated the subject of Pharmaceutical Chemistry are numerous; the generality of Chemists having bent their studies this way. Among the principal to be recommended for the service of this course, come Charas, Zwelfer, Dan. Ludovicus, Le Febure, Lemery, Wilfon, Staphorst, Barchusen, the Collectanea Chemica Leydensia, the Pharmacopœia Collegij Regalis Medicorum Londinensis, and Edenburgensis; Boerhaave's Chemistry, Quincy's Dispensatory, and Hoffman's Observationes Physico-Chymicæ.

IV.

Scheme for a Course of Metallurgical Chemistry; or, the Art of preparing Metals for Human Uses.

The Metallurgia Vulgaris.

Foundation of metallurgy. I. THE general foundations of metallurgy, as it regards the discovery, sinking, draining, and working of mines; with the manner of erecting the smelting-huts, and furnaces for separating the metal from the ore, in the larger works.

Two original books for this purpose, are Agricola de Re Metallica, and Ercker's Aula Subterranea.

Preparation of the ore.

II. The previous chemical operations required to fit ores for the furnace; viz. roasting, stamping, washing, and sifting; with the best methods of dispatching this business, suitably to the nature of the ore; or as it contains gold, silver, copper, or tin.

Besides the Authors just mention'd, consult upon this head, Dr. Stahl's Metallurgiæ Pyrotechnicæ, & Docimasie Metallicæ Fundamenta.

Assays of ores.

III. The particular methods of taking proof, or making assays of all kinds of ores, before they are smelted; so as to discover what proportion of pure metal

metal they contain; with the way of reducing all metallic substances to a regulus: whence a practical introduction to the art of chemical minerology, and the use of fluxes.

See as to this head Georg. Agricola de Re Metallica, and the Writers upon the Art of Assaying.

IV. The particular methods of smelting gold-sand, gold-ore, gold-fluds, *Smelting gold.* and silver-ore, so as to procure the largest yield; with the ways of casting the metal into ingots, bars, and blocks.

See Agricola, Ercker, Glauber, Becher, and Stahl.

V. The methods of separating tin, lead, bismuth, antimony, &c. and *Tin, lead, bismuth, &c.* casting them into blocks, pigs, or solid cones; as practised at the mine-works of *England, Germany and Hungary:* with the way of separating and purifying quicksilver.

See the Authors above-mention'd; and the Philosophical Transactions.

VI. The common ways of running copper and iron from the stone; and *Copper and iron.* of refining them into soft, ductile metal, or forming them into plates and bars. The art of making the purest copper, and toughest iron, for the more curious uses: with the best ways of case-hardening iron, and turning it to the finest steel.

To this purpose consult Agricola, Ercker, Becher, Stahl, Reaumur, and certain Papers in the Philosophical Transactions.

VII. The methods in use for extracting gold and silver from the baser *Extracting gold, and silver.* metals, at the larger works of *Germany, Hungary, and England.*

See Agricola, Ercker, Stahl, and Homberg, who has a curious Paper in the Memoirs of the Royal Academy, that affords a hint for the improvement of this affair.

VIII. The whole art of refining the nobler metals; as practis'd among *Refining.* the refiners of *London.*

Dr. Merret has a Paper upon this Subject in the Philosophical Transactions; which may be compared with Agricola's Description of the Art, at the close of his work de Re Metallica.

IX. The art of assaying plate, coin, and ores; as practis'd among the *Assaying goldsmiths and common refiners of London.* goldsmiths and common refiners of *London.*

See upon this head Agricola de Re Metallica, Ercker, and Olai Borrichij Docimaestice.

X. The several ways of coating or overlaying one metal with another; *Gilding, tinning, &c.* whence the art of gilding, silvering, tinning, and quick-silvering.

There are some Papers upon this Subject in the Philosophical Transactions, and French Memoirs; and the foundations of the thing are delivered by Barchusen, towards the Close of his Pyrotechnia, or Elementa Chemicæ.

XI. The art of soldering in the different kinds of metals; with the *Solders.* manner of preparing all sorts of solders for the uses of tin-men, brasiers, copper-smiths, pewterers, silver-smiths, and gold-smiths.

Some few hints to this purpose may be found in Mr. Boyle's Philosophical Pieces, and Barchusen's Pyrotechnia.

Electrums.

XII. The art of mixing metals and metalline substances, so as to form compound metals, electrums, brass or latton, cannon-metal, pin-metal, white-metal, *Basb*-metal, and all the mix'd metals in use.

For hints to this purpose see Houghton's Letters, the Philosophical Transactions, Barchusen, and Stahl.

Wire.

XIII. The art of wire-drawing, or forming metals into wire, of various sizes for various uses; with the different manners of gilding it.

To this purpose there are some hints in Mr. Boyle's Philosophical Works, and the Philosophical Transactions.

Tinging metals.

XIV. The art of colouring the whole substance of metals, so as to make white copper, white gold, yellow silver, &c. with the certain ways of detecting impositions of this kind.

See Boyle, Becher, Barchusen, Boerhaave, and Stahl.

Amalgams and vitriols.

XV. The ways of dissolving all metals with suitable menstruums, or reducing them to vitriols, and amalgams, for particular metallurgical uses.

See Hollandus, Becher, Homberg, Stahl, and the common books of chemistry.

Vitrification of metals.

XVI. The ways of converting metals into glass; particularly lead and antimony, for the business of assaying and testing of silver and gold, and the making of powerful fluxes for stubborn ores.

See Agricola, Ercker, Becher, Stahl, Borrichius, and the common chemical Writers.

Casting.

XVII. The more curious experiments in the art of foundery or casting of metals; particularly the way of casting in iron, so as to make works as beautiful as in hammer'd iron.

M. Reaumur has publish'd a book upon this subject; an account whereof is given in the French Memoirs.

Smithery.

XVIII. The more curious metallurgical experiments in the art of smithery, extracted from the practices of gold-smiths, silver-smiths, brasiers, copper-smiths, tin-men, pewterers, iron-smiths, gun-smiths, lock-smiths, &c.

Some particulars to this purpose may be found in the French and German Writers upon the arts of foundery and smithery; Mr. Boyle's Works and the Philosophical Transactions.

Particular extractions.

XIX. An attempt to introduce certain curious, or more conceal'd processes of metallurgical chemistry into the vulgar art of metals: as the method of extracting silver from tin; gold from silver; gold from sand, &c.

See upon this head Glauber, Becher, Boyle, and Stahl.

Minera perpetua.

XX. An experimental inquiry into the validity of *Becher's Minera perpetua*, or the art of procuring gold and silver, with moderate profit, from common mineral, or cheap metalline matters.

Dr. Stahl has a paper to this purpose, entitled de Metallorum Emendatione, modico fructu, profutura; which may serve to regulate the conceptions of Glauber and other Chemists upon the same subject.

Besides the few Authors already indicated, consult certain Pieces of Paracelsus, Glauber, and Kunckel; Webster's Book of Metals, Alonso Barba, Dr. Lister, and Dr. Woodward.

A Scheme

V.

A Scheme for certain Courses of the Chemia Curiosa: or, Sets of such chemical experiments as are more entertaining than profitable; yet suited to the improvement of Philosophy and Arts.

(I.)

Certain curious chemical experiments relating to natural philosophy.

I. **T**O shew the chemical nature, generation, production, changes and destruction of light, fire, flame and fewel; by means of the various kinds of phosphorus, and Hoffman's phlogistic liquor; with a particular inquiry into Stahl's phlogistic, and Homberg's sulphureous principle. *Nature of light, fire, and fewel.*

See Boyle, Homberg, and the younger Lemery upon the subject of phosphori; Boerhaave and Newton, upon the nature of light, flame, fire, &c. Homberg's essays upon the chemical principles, and Stahl's several pieces in metallics.

II. The chemical generation, changes, and destruction of cold and heat; illustrated in a variety of experiments. *Changes of cold and heat.*

To this purpose see the experiments of the Lord Bacon, Mr. Boyle's History of Cold, and the accounts of certain cold fermentations and effervescences in the French Memoirs, by M. Homberg and others.

III. The chemical generation, changes, and destruction of colours, exemplified by a set of curious experiments. *Colours.*

See Boyle on colours, Newton's optics, and certain papers in the Philosophical Transactions, and French Memoirs.

(II.)

Uncommon experiments relating to animal arts.

IV. Attempts to preserve animal flesh sweet, without salt, in long sea-voyages. *Flesh preserved.*

See Glauber, Boyle, and those who have wrote the natural history of sugar.

V. Attempts to introduce certain new colours into the arts of dying and callico-printing; particularly a permanent blue, capable of being impress'd or laid on without dipping. *New colours for dying, &c.*

See Blancour's art of glass ad finem; and the travels of Naturalists who give any accounts of the Indian pigments and colours.

VI. Attempts to improve the art of embalming; particularly by the use of the amber varnish, so as to coat over a human body with amber. *Embalming.*

See Boyle, Boerhaave, and Hoffman.

VII. Attempts to introduce certain new matters for anatomical injections, that shall shew the parts in their natural state. *New anatomical injections.*

For hints to this purpose see the anatomical works of Ruysch; and Homberg's paper upon the subject.

(III.)

(III.)

Experiments relating to vegetable arts.

Wines improved.

VIII. Attempts to imitate the wines of the first growths of *France*, and of the *Rhine*; and the richest wines of *Italy*, *Hungary* and *Greece*.*See certain papers in the German Ephemerides upon this subject; and compare them with the doctrine and experiments of Glauber, Becher, and Stahl, made with the same view.*IX. Attempts to produce sound wines, vinegars, and tartar, from the vegetable juices of *England*; and distilling these juices into brandies of equal goodness with those of *France*, *Goa*, or *Batavia*.*See this subject considered by Glauber, with regard to Germany; and improved by Becher and Boyle.*

Teas imitated.

X. Attempts to imitate or exceed the teas of *India*, the coffee of the *Levant*, and the chocolate of the *Isles*, by means of commodities of *English* growth.*To this purpose consult certain papers in the German Ephemerides.*

(IV.)

Experiments relating to the *Metallurgia Sublimior*.

Mercuries of metals.

XI. The more rational attempts to reduce all the metals to their running mercuries, or extracting a proportion of mercury from them.

See Basil Valentine, Paracellus, Boyle, Becher, Homberg, and Stahl.

Butter of metals.

XII. The conversion of metals into a butyraceous or waxy substance.

See Hollandus de Salibus & Oleis Metallorum, and Homberg's paper as to a certain matter running thro' the solid body of metals, like water thro' a sieve.

Whether transmutation be possible.

XIII. Experimental attempts to convert mercury into metal, iron into copper, and silver into gold; with an account of the fallacies and gross impositions discovered in this affair.

(V.)

Uncommon Experiments relating to the mineral arts.

Varnish and china.

XIV. Attempts to prepare varnishes and porcellane-ware, exceeding those of *China* or *Japan*.*See certain papers in the philosophical transactions, French Memoirs, and German Ephemerides.*

Fine copper.

XV. Attempts to imitate tutenag, the white and red copper of *Japan*, and the finest bar-copper of *Germany*.*See Dr. Woodward, Stahl, Homberg, and the professed metallurgists.*

XVI,

XVI. The most promising methods of making malleable iron with pit-coal, in the large way. *Malleable iron with pit-coal.*

See Dr. Stahl, in his several curious pieces upon iron.

XVII. Attempts to make regulus of antimony malleable. *Regulus of antimony softened.*

See Becher and Stahl upon the lead of antimony; and compare them with Boerhaave's doctrine as to the reduction of antimony to silver.

(VI.)

Chemical experiments relating to pharmacy and medicine.

XVIII. Attempts to imitate the more celebrated mineral waters of Germany and England; as those of Pyrmont, and Bath, &c. from an exact chemical analysis thereof. *Imitation of mineral waters.*

See Mr. Boyle, Dr. Hoffman, and various papers of the French memoirs.

XIX. Attempts to imitate certain foreign drugs; as opium, camphire, Of drugs. balm of Gilead, oriental bezoar, nitre, sal-ammoniac, borax, &c.

See Pomet's history of drugs, and Savary's dictionary.

XX. Attempts to imitate or excel the vegetable essences, perfumes, and Of essences. fucus's of Italy and Spain.

See Paracelsus, Glauber, Boerhaave, Pomet, and Stahl.

(VII.)

Uncommon experiments relating to mix'd arts.

XXI. Experiments relating to the chemical production, alteration, Inks. destruction, and regeneration of colours, stains and inks; in cloths, silks, cottons and papers.

See Mr. Boyle, Dr. Merret, and M. Homberg.

XXII. Ways of making certain pernicious mixtures, capable of producing devastations. *Pernicious mixtures.*

See Lemery's paper upon earthquakes, lightning, &c. in the French memoirs.

See also Boerhaave's chemistry; and Dr. Hoffman's observations.

XXIII. Experiments relating to the more perfect ways of annealing and staining in glass. *Staining glass.*

See Neri, Kunckel, Blancour, the author of Sol sine veste, Becher, and Stahl.

XXIV. Attempts to convert all the metals into their specific glasses, without addition. *All the metals vitrifiable.*

See M. Homberg's chemical experiments with the great burning lens; and compare them with the operations of Neri and Kunckel at a glass-house fire.

XXV. Attempts to soften glass, or bring it towards a malleable state: and again, for giving it nearly the hardness of a diamond. *Glass made softer and harder.*

See Boyle and Homberg upon this curious subject; and compare them with Neri, Merret, Blancour, and Kunckel.

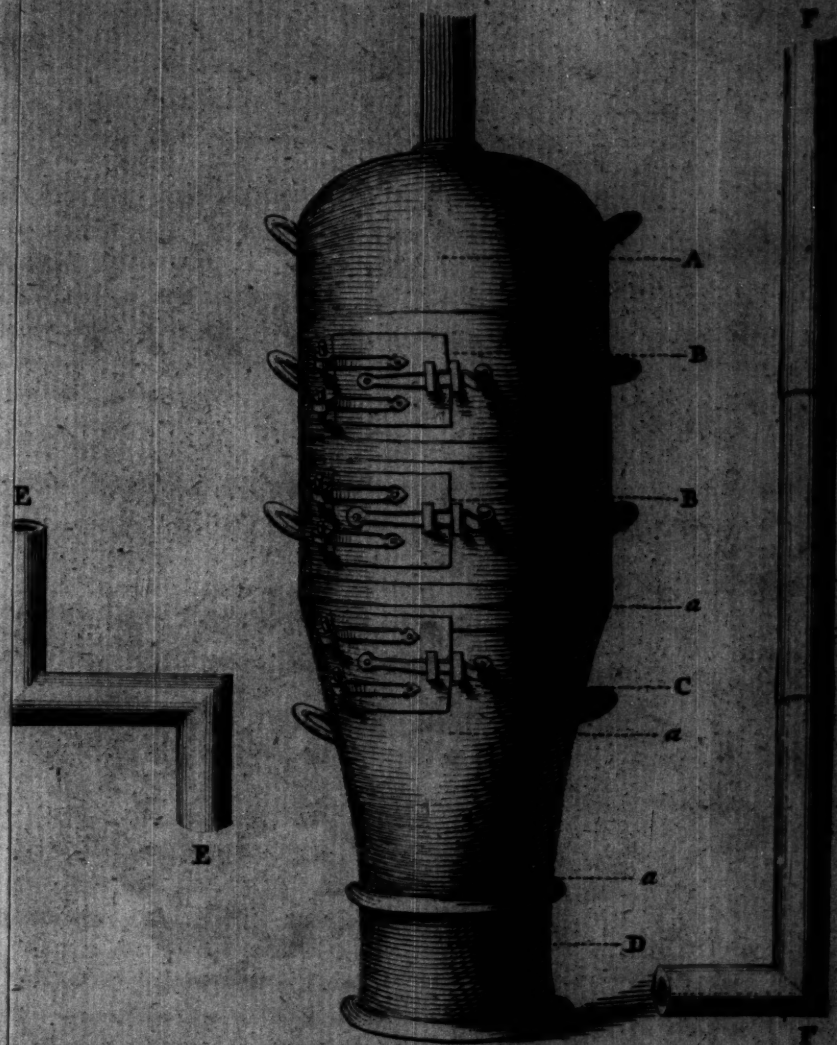
One might proceed to sketch out schemes for courses of recreative chemistry; shewing the artificial generation of meteors, new ways of illuminating roads and streets, making new kinds of fire-works, and exhibiting numerous other productions and phænomena of this art, in the way of what was antiently term'd natural magic: but thus much may suffice, for the present, to shew that the art has hitherto been too much confin'd, and deserves to be set free, or cultivated at large, for the advantage of mankind.

F I N I S .



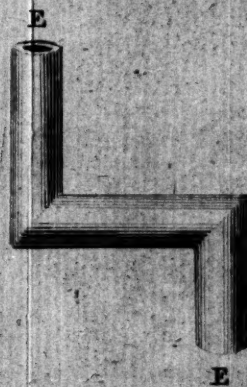
THE

Plate 1.



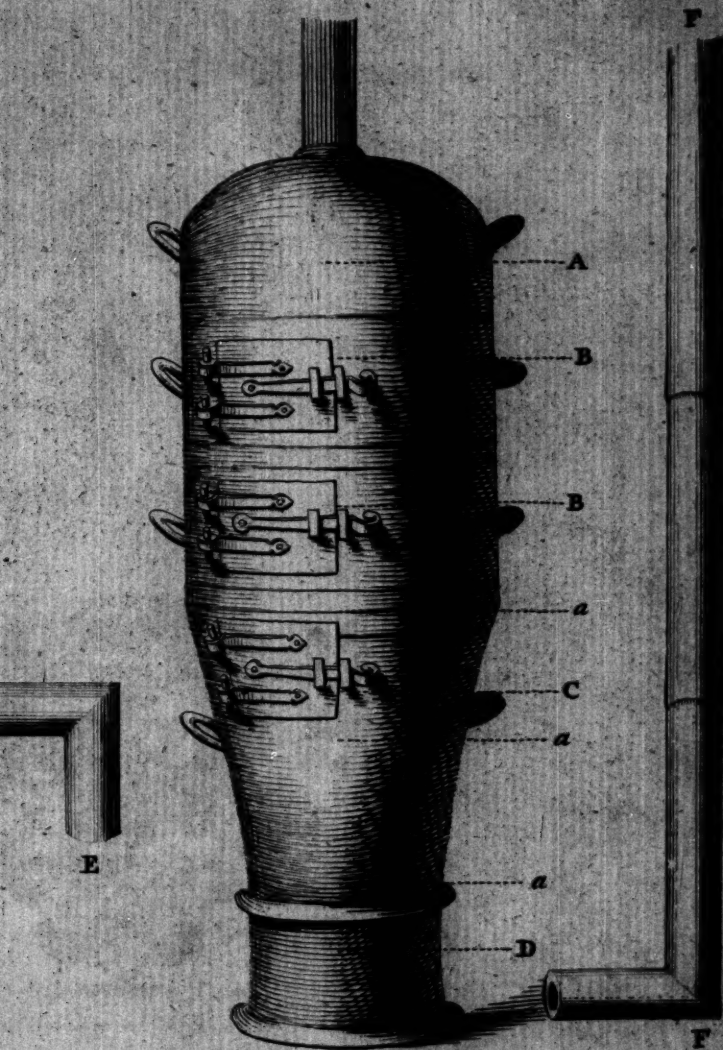
external View of the Furnace when all its parts are out of use
the Cover with its upright Funnel D. The close Foot
The two Rings a a a. The Place of the three grates
E.E. The Top Elbow Funnel
The Body F.F. The Lateral Funnel
the Seal.

Appendix.



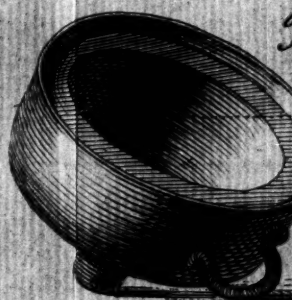
An external View of
A the Cover with its
B.B. The two Rings
C. The Body
J. vander Gucht Scul.

Plate I.



View of the Furnace when all its parts are out of use
 with its upright Funnel D. The close Foot
 Rings
 a a a. The Places of the three Grates
 E. E. The Top Elbow Funnel
 F. F. The Lateral Funnel

Appendix.



A. The Cover.

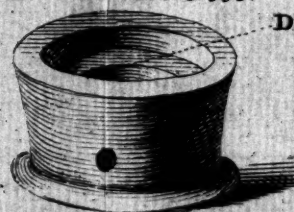
C. The Body.



A Black-Pot

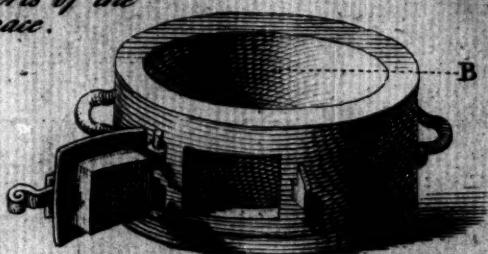
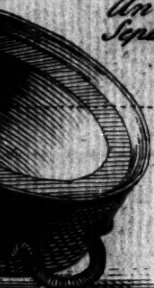


D. The close Foot.



Hander gucht-Soul.

Plate II.
An internal View of the
Separate Parts of the
Furnace.



B. One of the Rings.



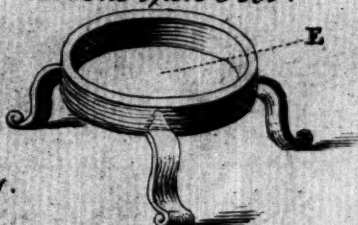
a. and b. are only
expletive, and represent
the first a black Crucible.
the other a Cementing Pot.



Foot.



E. The open Foot.



F. One of the Grates.



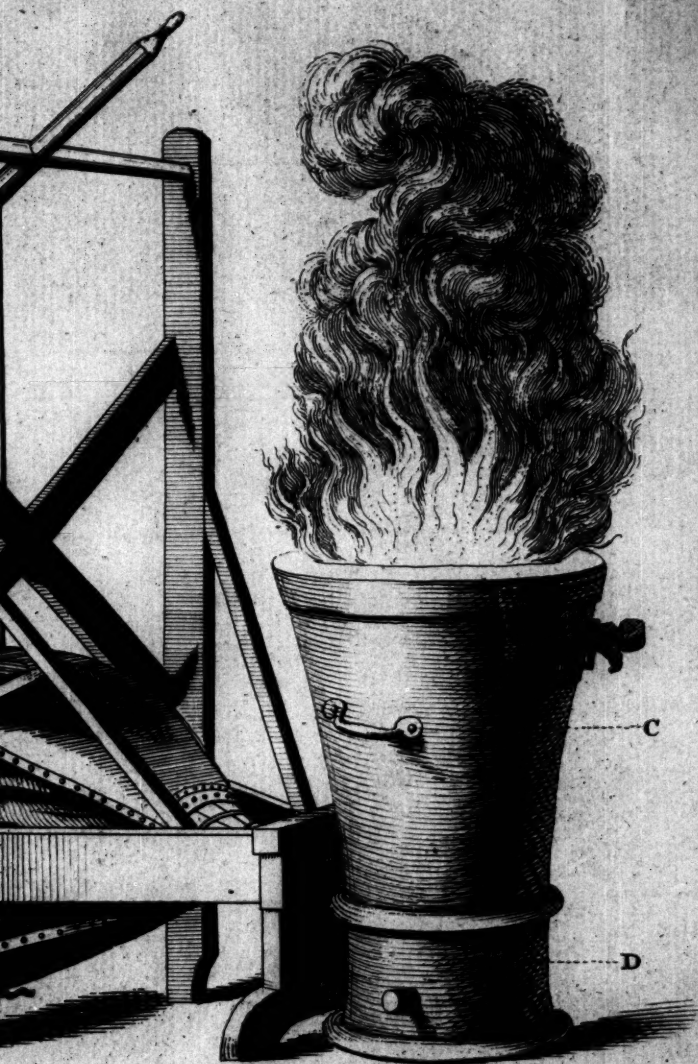
Appendix.



*A Smell
of the Body*

J. Vander Gucht Scul.

Plate III.



*A Smelting Furnace at Work, compos'd only
of the Body and close Foot, C, and D, without a Grate.*

Appendix

b

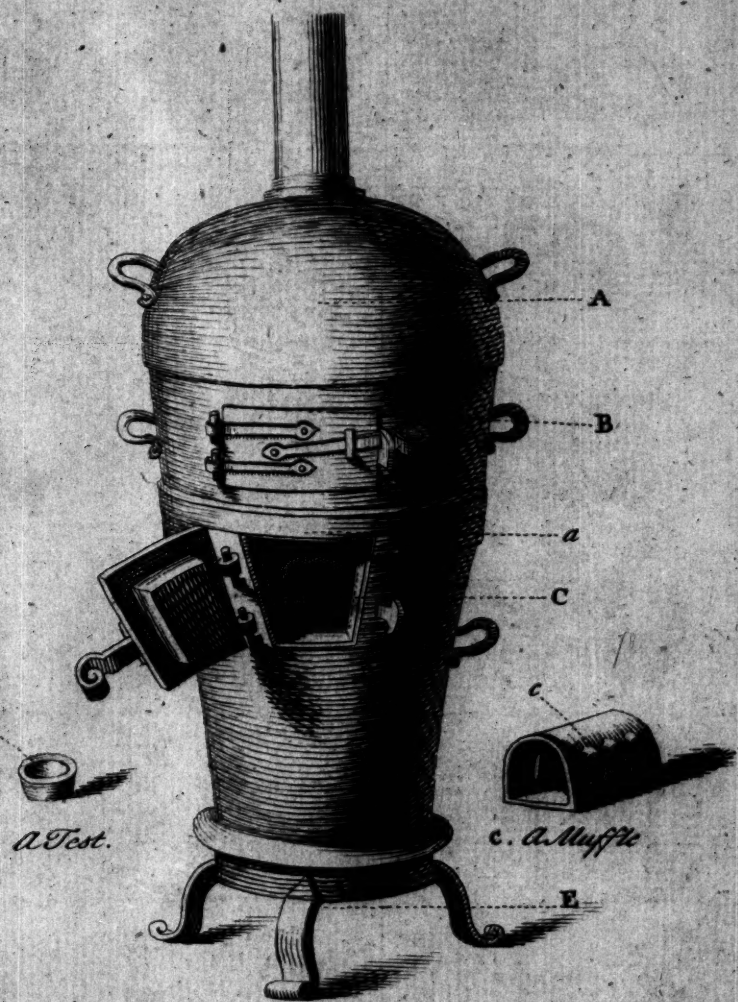


b. A Test.

*A Testing
and confis-
Funnel,
the Body*

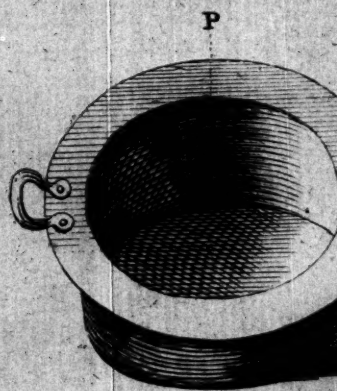
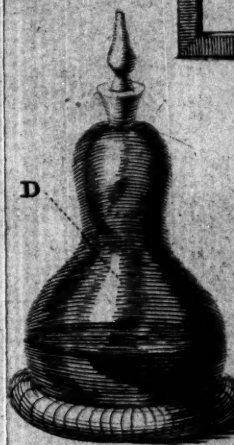
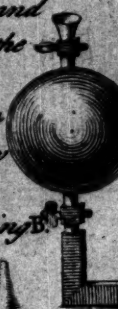
Wander Gucht Seal

Plate IV.



A Testing Furnace, preparing for the Operation;
and consisting of the Cover A. with its upright
Funnel; the Ring B; the top Grate placed at a;
the Body, C. and the open Foot, E

L. A Lamp (w stand
on the grate a. in the
Ring B.) with its
Ball of Oil or spirits
fitted on to the elbow
coming out at the
door-way of the Ring B.



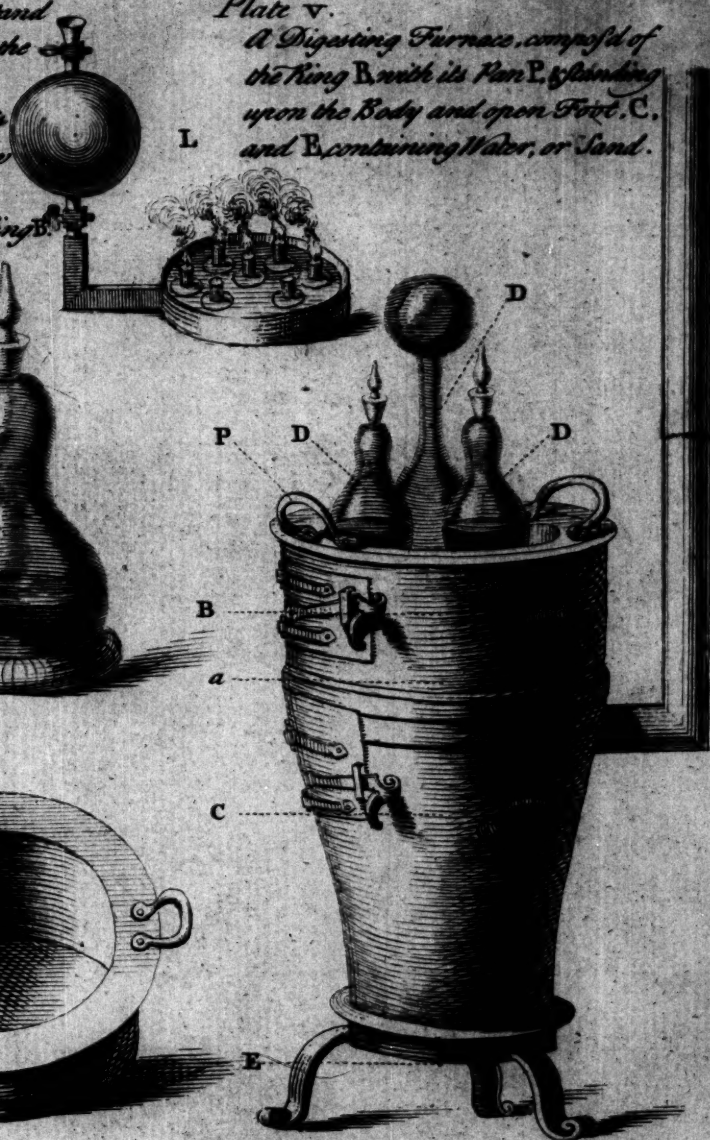
DDD

J Vander Gucht Scul.

Appendix.

Plate V.

A Digasting Furnace, composed of
the Ring B, with its Pan P, standing
upon the Body and open Port, C,
and E, containing Water, or Sand.



DDDD are digesting Glasses, and PP the Pan for
making a Balneum Mariae, or Sand Heat.

Appendix



*A Hot Still at work where
Head A; and the Vaisa or Cop
middle Grate being placed at a*

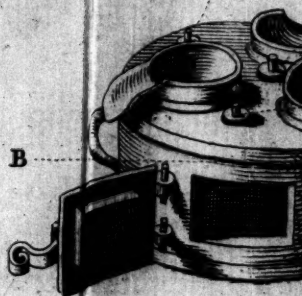
J. Vander Gucht Scul. X the Refr

Plate VI.



work where the common Cover is changed for a Pewter Still-
 lica or Copper Vessel, U, goes into the hollow Ring, B; the
 placed as in the Body C standing upon the open Foot E.
 the Refrigeratory containing its Pewter Worm.

H. An Iron Pot
represented out
of the Ring.



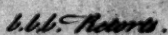
A Furnace for
distilling by the
Capolla vacua, where
the Ring BB. furnish'd
with three Iron Pots and
their covers, so as to con-
fine the Retorts without
any Sand between,
stands upon the Body
C. with its lateral
Funnel F. the middle
Grate at a. & the open
Foot. E.



Wander Licht Scul.

H

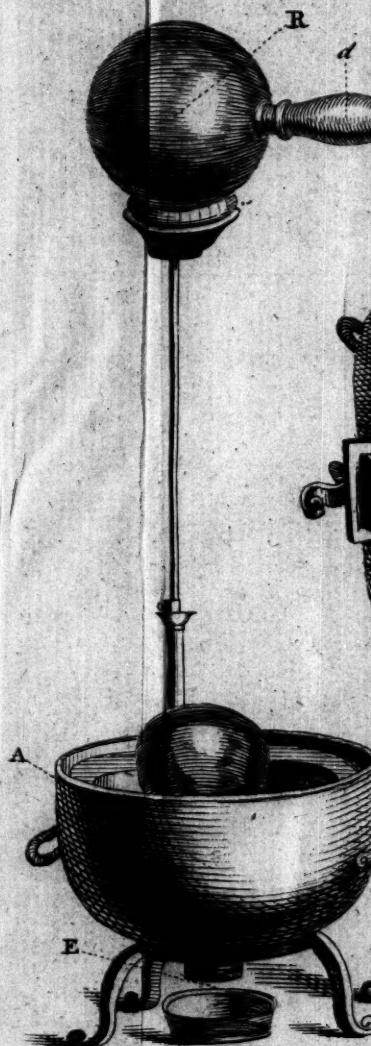
I. the Turn Cover of the Pot.



c.c.c. Receivers.

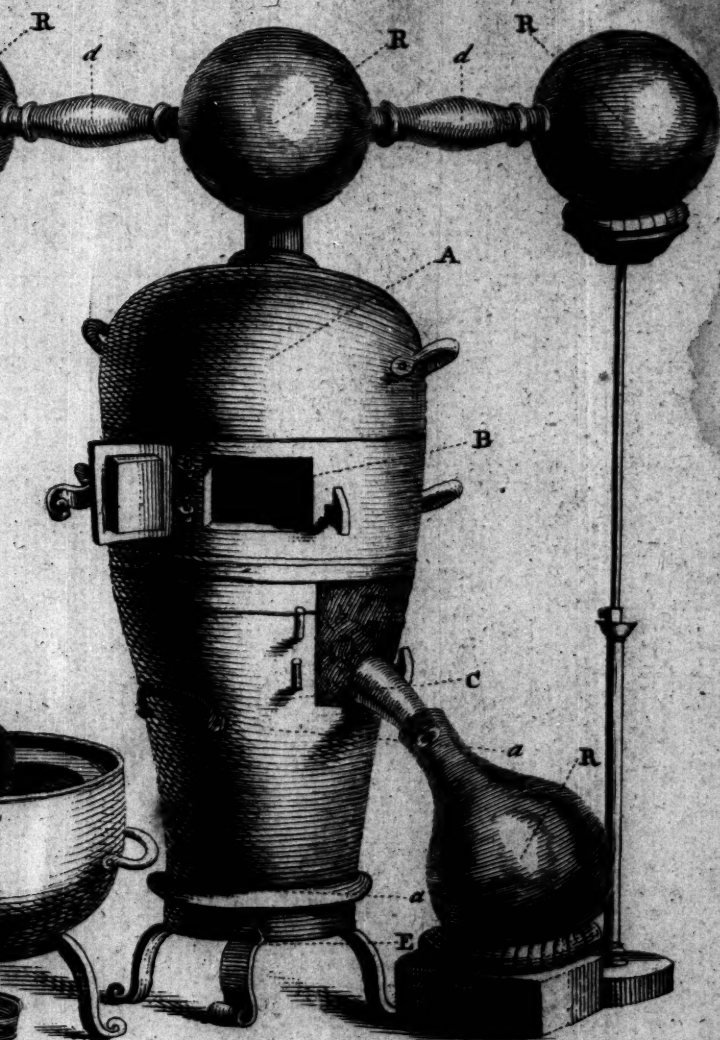
eee are loose
Supplies or Vents
to regulate the fire

Appendix.



*A Furnace for Sublimation and
Adopters &c. The Fire being either
at the Door of the Ring B; the whole
When the Fire is upon the lowest of
Body C, standing on the open Feet, &c.
J. Vander Gucht, Sc. When the
Furnace for*

Plate VIII.



operation and Distillation by a naked Fire with a Set of Receivers RRRR, and
 being either upon the lower or the middle Grate, the Matter may be thrown in
 B; the whole Furnace supplying the place of a distilling or subliming Vessel
 the lowest Grate, a, the Neck of the distilling Vessel comes out at the Door of the
 open Fire, E.

When the Cover A is inverted into the open Fire E, it makes a convenient
 Furnace for distilling per descensum as express'd in the Side Figure A.E.

THE INDEX.

N. B. The letter p. refers to the *Practice*, or third part of the book;
and the letter n. to the *Notes*.

A.

- A** *Cetum Radicatum*, what, 168 p
Acetous acids, what 547
Acid, a vague one, found in all parts of the earth, 112 & n. 113 n. 204 p. 267 p
 Its affinity with fume of sulphur, 112
 How it forms various fossils, *ib.*
 Whether procurable from animals, 202 p
Acid and Alkali, the doctrine, 339—341 p
 By whom well explain'd, 56 n
Acids, what, 341 p
 Distinguish'd from alcalies, *ib.*
 Consider'd as menstrooms, 546—555
 Their use how indicated, 218 p
 Given in fevers, 196 p. 202 p
 Are of two kinds, 546
 Mineral, which, 549, 263 p
 How they differ, 549
 Dissolve the hardest bodies, 549, 550
 Changed in the operation, 552
 Take up the mercurial part of metals, *ib.*
 Vegetable, which, 546
 Lost by much drying, 87 p
 Native, which; and their power in solution, 546
 Of unfermented vegetables, how got, 546
 Of fermented vegetables, which, 547
 The strongest rise latest in distillation, 137 p
 May be loosely lodged in metals, 297 p
 Determine alcalies, 261 p
 Whether naturally contain'd in animal bodies, 518, 546, 162 p. 193 p
 Assume a saline form with their solvents, 553
 See *alcalies* and *spirits*.
Acidum Esuriens, what, 138 p
Action in bodies, on what it depends, 507, 508, 509
Adam said to be an alchemist, 16
Additions in working, the use, 36, 37 p
Adepti, who, 26
Adopters, what, 585
Aerugo, what, 91 n
Aethiops mineral, how made, 313 p
 May be form'd naturally, *ib.*
 Its properties and uses, *ib.*
Agricola (*Geo.*) his book *de re metallica*, 49 n
 His character, *ib.*
Agus, how cured, 29 p. 31 p. 67 p. 95 p. 102 p. 206 p. 229 p. 246 p
Air, what, 379 & n
 An almost universal agent, 381
 Animates fire, *ib.*
 Actuates animals, vegetables and fossils, 382
 Its action in the bowels of the earth, *ib.*
 Necessary to the production of animals, 383
 Its knowledge necessary, *ib.*
 Its fluidity, *ib.*
 Owing to its fineness of parts, 384, 585
 Lubricity of its parts, 385
 Mutual attraction of its parts, *ib.* & n
 Expanded by fire, 224
 Miscibility of its parts, 386
 Degree of its expansion, 225
 Its imperceptibility, *ib.*
 Always in motion, 226
 Its absolute gravity, *ib.* & n
 Its relative gravity, 387
 Variableness of its weight, *ib.* & n
 Its weight compared with water, 387
 Effects of its weight, 388 & n. 389—391
 Its elasticity, 391 & n
 Peculiar to it, 392
 Law of its elasticity, 392
 How far carried, *ib.* 393
 Its elasticity unalterable, 394
 A single particle not elastic, 395
 Condensed air a fluid, *ib.*
 Its spring equal to its weight, *ib.* & n
 A small part equal in force to a large one, 396
 More rarifiable by fire than other bodies, *ib.*
 Of the same density, equally rarified by the same heat, 397
 Air,

I N D E X.

- Air*, the natural quantity of heat contain'd in it, 226
 Dense air made more elastic by the same degree of fire, *ib.* & n
 Condensed by cold, 398, 226, 227
 Its spring not destroy'd by fire, *ib.*
 Whether capable of the gravity of gold, 303
 Its contents, 399 & n
 Fire therein, *ib.*
 Water therein, 399, 400
 In fixed alcali, 400
 Dew therein, 401
 Power of elastic moist air on bodies, 406 & n
 Spirits of vegetables in it, 408 & n
 Oils in it, 409
 Salts in it, *ib.*
 Earths in it, *ib.*
 Parts of animals in it, *ib.* & n
 Fossils in it, 410 & n
 Sulphurs in it, 412
 Metals in it, *ib.* 413 & n
 Its internal nature, 414—418
 A particular virtue in it, 418
 Adheres to solids 420
 To fluids, 421
 To itself, *ib.*
 In water, 422—424
 Re-absorb'd by water, 424
 Does not enter water already saturated, 425
 Diffuses itself thro' the whole bulk of water, *ib.*
 Separated by boiling, *ib.*
 By freezing, 426
 By alcali, 427
 Obtained from the warm fluids of animals, *ib.*
 Its quantity in water, 429
 In water, is not air, 430
 Its elasticity from union, *ib.*
 Its particles very penetrating, *ib.*
 Its entire body not very penetrating, *ib.*
 Obtain'd from vinegar and crabs eyes, 431
 From chalk, 431
 From oil of tartar and vinegar, *ib.*
 From oil of tartar and oil of vitriol, 432
 From spirit of nitre and iron, 433
 From spirit of nitre and oil of caraway, *ib.*
 Produced from bodies by fire, *ib.*
 Divided into transient and permanent, 379 n
 Wholesome or unwholesome, whence, 416 n
 Hot, its surprizing effects on animals, 294
 In some countries how it affects certain colours, 407 n
 Its heat in respiration, 293
 Present in all chemical operations, 434
 Structure of its particles, 379 n
 How to produce it, 379 n
 Generated by gunpowder, *ib.*
 Its repelling force, 385 & n
- Its pressure, 386 n. 389
 Its variation, how it may influence health, 387 n
 If compressible *in infinitum*, 393 & n
 Rule of its dilatation, 395 n
 May produce earthquakes, 397
 Whether capable of the gravity of gold, 397 n
 Increase of its spring, *ib.*
 An aggregate of effluvia from different bodies, 399 n
 May cause thorough solutions, 406 n
 Qualities ascribed to it, owing to a more subtle medium, 419 n
 May have a peculiar corrosive or dissolving power, 406 n
 Its effects on fire, 381
 Whence necessary to fire and flame, 371 n, 381 & n
 Abounds in acid vapours, 407 n
 Causes putrefaction and fermentation, 407 n
 Many of its effects not accountable for, *ib.*
 Can change the subjects of the vegetable kingdom into the animal, 408 n
 Exhalations therein, *ib.*
 Contains all sorts of menstruums, 406 n. 435
 Its effects on stone, 413 n
 Saline effluvia contained therein, 409 n. 410 n
 The particular species how determined, 415 n
 Its alterations by heat and cold, drought and moisture, 415
 By the heavenly bodies, 415 n
 Unites with other particles, 434
 Mixes bodies among one another, *ib.*
 Its effects on bodies, 434, 435
 Fixes volatile, and volatilizes fixed bodies, 435
 Calls forth the latent powers of bodies, *ib.*
 Contains active principles, *ib.*
 See *Atmosphere*.
- Albertus Magnus*, his character and writings, 27 & n. 28 & n
Alchemists, to discover their imposture in making of gold and silver, 70 n. 71 n. 84 n. 85 n
 Why not always successful, 201
 Their general principle, *ib.*
 Their pretensions, besides the philosophers-stone, 154, 203
 Sum of their doctrine, 201, 202
Alchemy, the word when and by whom introduced, 15 & n
 Its technical meaning, *ib.* & 25
 Its antiquity examined, 15 & n. 16 & n. 17, 18
 Wherein it consists, *ib.* & 202
 On what it depends, 315 p.
 Pretends to make gold and find an universal medicine, 15 n. 200
 The best writers thereon, 26 & n. 53, 54
 Alchemy.

I N D E X.

- Alchemy*, Greek writers on it, 18, 19, 20
Alchymy, what, 116 n
Alcohol, what, 124 p
 How procurable to advantage, 527, 124, 125 p
 To examine its purity, 126 p. 317
 Its properties, virtues and uses, 125 p. 126 p
 Is a compound body, 129 p. 329
 Contains an oil, 129
 Not miscible with oil of tartar, 126 p
 Wets not saline bodies, 127 p
 Not easily changed, 127 p. 129 p
 Its great volatility, 125 p
 Why mortal when too freely drank, 125 p. 222 p
 Coagulates the animal fluids, 329, 125 p. 221, 222 p. 238 p
Per se, how prepared, 124, 125 p
 How prepared with fixed alcali, and united therewith, 127, 128 p. 172 p
 Nature, virtues and uses, 128, 129 p. 214 p
 Whether attainable in absolute purity, 129 p
 When improper for tinctures, 44 p. 148 p
 What it extracts from vegetables, 147 p. 148 p. 169 p. 172 p
 Its affinity with oil, 174 p. 180 p
 May be used to adulterate the richer oils. 174 p
 Distilled from oil of vitriol, 275 p
 Into what forms convertible, 172 p
 Whether reducible to water or earth, 162. 474 n
 Externally used may cause cancers 214 p
 Has no attenuating power in the body, 215 p
 Its embalming virtue, 125 p. 222 p
 Stops the growth of animals, 222 p
 Alter'd by salt of tartar, 527
 Whence its inflammability, 315
 The purest of all fowels, 315. 327. 329, 330
 What bodies it dissolves, 527
 The same from all vegetables, 329
 Separable from water, 324
 The only pure inflammable substance, 327
 Sustains flame of itself, 328
 Yields no smoke, *ib.*
 Its great rarification, 232
 In perpetual motion, 233
 Preserves fire and flame, 316, 317
 Miscible with water and oils, 327. 452
 Yields no ashes, 328
 Greatly resembles sulphur, 329
 A magnet of fire, *ib.*
 A secret menstruum, 526
 May unite with fixed alcali, 527
 The bodies it dissolves, *ib.*
 Why it will not touch sulphur, 267 p
 See *Spirit of Wine*.
Almbic, what, 585
 Its structure and use, 585, 586
 To prevent its burning, and the head from flying off in working, 118 p
Alkabest, origin and derivation of the word, 571
 How and where spoke of by *Paracelsus* and *Helmont*, 570, 571, 573
 Origin of the thing 572
 Pretensions of several chemists to it, 570
 Its effects in changing bodies, 447 n. 573. 574. &c.
 Its properties, 571. 576
 Whether possessed by *Helmont*, 571. 580
 Unknown to *Boyle*, 570
 For what mistook by *Zwelfer*, 564. 579. 138 p
 Whether volatilized salt of tartar 579. 166 p
 What esteem'd by *Glauber*, 579, 252 p
 Conjectures as to its matter, 579, 580
 Words of like import therewith, 571, 572
 Differently spoke of by *Helmont*, *ib.*
 Is the product of art, 572
 A greater *arcuum* than the Philosopher's Stone, 569, 570
 Changes all things but water, 576
 In what order it changes bodies, 574. 575
 Its manner of application, 574
 Destroys not the seminal virtues of bodies, 575
 Might produce a genuine *aurum potabile*, 575
 The bodies dissolved by it, raised in a sand-heat, 574
 Leaves the solvent elementary earth, 573. 576
 Applied to charcoal, 573
 Not impaired in solutions, 575, 576
 Why called the immortal liquor, 576, 577
 Is incapable of mixture, 575
 The manner of its action, 574, 575
 Various opinions concerning it, 579
 Not prepared from urine, *ib.*
 Not phosphorus, *ib.*
 What it probably was, 576. 578, 579, 580
 Whether the same with the *sal circulatum* of *Paracelsus*, 571. 578
Alkalies, what, 530
 Their exhibition how indicated, 90 p
 How prescribed to advantage, 238 p
 See *Spirits, Salts and Acids*.
Alkali, fixed, what and whence readily obtain'd, 529, 530. 534. 33. 34 p. 242, 243 p
 Consider'd as a menstruum, 529—546
 The name whence, and how varied, 529
 How it is known, 530. 37 p
 How made to act as a menstruum, 546
 How best purified, 532
 Its use in preparing bodies for solution, 565
 How produced, 530. 33. 34 p. 242, 243 p
 Attractive of moisture, 530. 535. 36 p. 171 p
 Changes colour in the fire, 34 p. 171 p
 Destructive of animal substances, 35, 36 p
Alkali.

I N D E X.

- Alkali, fixed*, its numerous properties, 530,
35—37 p
Alterable by the salts of the air, 36 p
Recovers salts from their acid spirits, *ib.*
Repels, or strongly attracts air, 536
Its corrosive power, 35, 36, 37 p
All of the same nature, 534
How made volatile, 36 p
Whether a production of art, 37 p
Its medicinal virtues and uses, 37, 38 p
With what cautions to be administered, 38,
39 p
How run *per deliquium*, 36 p
Liquid, how procur'd pure, 36 p
Differs in purity, 524
Its gravity, 36 p
Attracts pure alcohol, 537
Oils, *ib.*
Acids, 538
Its action on bodies, 545
See *Salts fixed*.
Alkaline disposition of the body, 90 p
Alum, what, 111
Its kinds, 112 n
Whether a proper salt, 111
Its origin, *ib.*
Where found, 112 n
Its generation, 111, 112
How made in *England*, 112 n
Its stone, *ib.*
How made at *Civita Vecchia*, *ib.*
Its use in making spirit of nitre, 87 n
Rock-Alum, what, 112 n
How made at *Selfaterra*, *ib.*
How found in the earth, *ib.*
Amalgamation of metals explain'd, 76, 77 n
The general method thereof, 315, 316 p
Its use, *ib.*
Amber, what, 118 & n. 119 & n
Whether vegetable, animal, or fossil, 118 n
Where found, and in what form, *ib.*
Whether once fluid, 119 n
Mixed with foreign bodies, *ib.*
Its tastes and scents, *ib.*
Its menstrua, *ib.* 144 p
Its tincture gain'd readily, and the virtues
thereof, 144, 145 p
How analysed, 179 p
Its oil, salt and spirits gained, *ib.*
Possibly a camphor, 180 p
Virtues of its salt and oil, *ib.*
Ambergrease, what and where found, 119, 120 n
Its origin, 119 n
Various opinions about it, *ib.*
Its uses, 120 n
Amethyst, what, 123
Ammon, the meaning of the word, 11
Analysis, Chemical, productions thereof, 158 n.
167, 168 & n
In what manner conducted, 1—6 p
Anatomical Preparations, how preserved, 92 p
95 p. 125 p. 143 p
Animals defined, 66 n. 148 & n
Distinguish'd from vegetables and fossils,
148 & n. 151
Have their atmospheres, 150 n
Their solids of what composed, 153, 184,
185 p
Unchangeable, 185 p
Their fluids what and whence derived, 153
How distinguish'd chemically from those
of vegetables, 154 & n
Coagulable by heat, 214
Yield no fixed alkali, 152
Contain no real acid, *ib.*
Their principles, 151, 152, 170 n
All their matters afford the same principles,
185 p. 225 p
Have each a peculiar spirit, 151. 168
Contain much water, 152
A salt, and of what kind, *ib.*
No fixed salt, *ib.*
Contain an oil, 152
Consider'd as the subjects of chemistry, 148
Into what resolvable, 151, 152
Want the faculty of forming salts, 42 p.
202 p
Their salts whence derived, 42 p. 204 p
How preserved by smoke, 86, 87 p
Are continually wasting and repairing, 184 p
Their food, and how they are composed
thereof, 184, 185 p
May have some of their aliment and oil from
the air, 184 p
Their growth how stopped, 222 p
Their bodies consist of vegetables, 2 p.
184, 185 p
Their parts might once exist in milk, 186 p
Naturally contain neither acid nor alkaline
salts, 185, 212 p
Animal Exhalations, inflammable, 335
Animal Matter, its growth like that of fossil,
150 n
Anodyne, in oil of turpentine, 95 p
Antimonium diaphoreticum nitratum, 329 p
Its virtues, uses, &c. *ib.*
Dulce, how made, 330 p
Its ill effects on the body, *ib.*
Helmontii, how made, &c. 336 p
Antimony, its chemical character explain'd, 68,
69 n
Its various names in chemistry, 71 n
What and where found, 132 & n
Its nature, *ib.*
Its use in cupellation, 71 n
Volatilizes all metals but gold, *ib.* 132
The last test of gold, 71 n
Emetic virtue of its glass, 122 n. 323 p
Nature of its sulphur, 321, 322 p
Antimony,

I N D E X.

- Antimony*, consists of a metalline and sulphureous part, 132, 321, 322 n. 323 p
To purge it of its sulphur a *desideratum*, 132
Attempts to render it a metal, *ib.*
Whether capable of resolving gold, *ib.*
Where and in what forms found, *ib.* n
Of two kinds, *ib.*
The common, what, *ib.*
Its power in dissolving metals, 490
Whether it destroys their nature, *ib.*
Its virtue and uses, 132 n
How dissolved in *aqua regia*, 321 p
How purified by bare fusion, 322, 323 p
With flux-powders, 323 p
Its calcination, 322, 323
Its golden sulphur, how procured, 328
Virtues and uses thereof, *ib.*
Its *crocus*, or liver, how prepared, *ib.*
Its glass, what, and how made, 322, 323 p
A mild emetic, how made from it, 329 p
Its vomitive poison corrected by nitre, *ib.*
Its diaphoretic nitre, 330 p
Its fixed sulphur how obtained, with the nature thereof, 330, 331 p
Its butter or icy oil, what, and how made, 331, 332 p
Poisonous nature thereof, 332 p
Its conversion into oil, with the uses thereof, 333 p
Its conversion into *Mercurius vitæ*, 333, 334 p
Its emetic flowers how prepared, 335 p
Variety of colours producible therein, 336
Its fixed flowers how made, *ib.*
Helmont's purging flowers thereof, and their virtues, 336, 337 p
Apoplectic balsams, how prepared, 102, 103 p
How to colour them differently, 103 p
Their uses and virtues, *ib.*
Apocyni, what, 13, 14 p
Wherein they differ from infusions, 15 p
How made to the best advantage, 14, 15 p
83 p
See *Decoction*.
Aqua fortis, what, 87 n. 255 p
How made, 87 n. 254 p
Its use in separating gold and silver, 87 n.
To try its purity and make it proof, 87 n.
294 p
The metals it dissolves, 551
Aqua regia, whence its name, 73 n
What, and how prepared, 73, 87 n. 258 p
Its use in separating gold, 77 n
What bodies it dissolves, 552
How made to dissolve silver, 88 n
Archæus, *Helmont's* notion thereof, 45 n
Armenian stone, what, and its use, 124 n
Arnoldus de Villa Nova, his history, writings, and doctrine, 31 & n. 32 & n
Aromatics, wherein their virtues reside, 149 p
153 p
Areph, or *Aroma Philosophorum*, what, 133
152 p
Arsenic, its poisonous nature, 115, & n
Worked for gold, or the philosopher's stone, 17, 115 & n
How obtained from cobalt, 116 n
White and red, 115, 116 & n
Crystalline, whence obtained, 116
The common, which, *ib.*
Makes metals brittle, 117 n
A peculiar menstruum for it, wanted, 117 n
Changes copper like silver, 116 n
Insoluble in water, 117 n
Greatly alters metals, *ib.*
Dangerous to handle, 116 n
Art, what, 66
Whence definable, 65 n
Arctophilus, an author in alchemy, 54 n
Asclepius, the inventor of chemistry, 14
Asbus, what, 307, 308, 18, 19 p
How made consistent and hard, 475, 20 p
How gained insipid from vegetables, 18, 19 p
How gained saline from vegetables, 21 p
Retain the figure of the plant, 19, 22 p
What they contain, 19, 20 p
Of all vegetables, vitrifiable, 33, 36 p
Those of distilled and fermented vegetables, 55, 56 p
Asphaltum, what, 117, 118 & n
How sophisticated, 118 n
The ancient or supposed mortar of the walls of *Babylon*, 118 n
Asphma's, whence, 249
Assaying, the foundation of that art, 71 n
Astroites, what, 123
Atmosphere, effects of light or fire therein, 234
Whence heat and cold therein, 266
A chaos of all things, 399 & n. 408 & n. 414
Its phenomena accounted for, 270
Unites fire to its pabulum, 222, 333
The exhalations therein, 408
Its weight, 386, 387
Its different weight, 234
See *Air*.
Atoms, what, and their hardness, 159, 160, 166 n. 167 n
Attraction, its notion explained, 155 n. 156 n
Its species, *ib.*
How far known, *ib.*
Attrition, what, 238 n
How, and in what proportion it collects fire, 236—243
Avicenna, his chemical writings, 27 n
Auripigmentum, what, 115, & n
Aurum fulminans, how made, 74, & n. 317 p
Aurum Philosophorum, what, 71 n
Its great simplicity, *ib.*
Aurum potabile, 78 n
Of the *Magi*, 281 p
Of *Paracelsus*, 276 p
Aurum

I N D E X.

- Aurum potable*, made by bare motion 502 & n
 Procured from all metals ground with water, 502
 A sham one how made, 260 p
Azoth, what, 26
Azure, what, and how prepared, 133 & n
- B.
- BACON** (*Roger*) his history, character of
 his writings, chemical doctrine and experiments, 28 & n.—31
 Condemned for a magician, 31
 Acquainted with gunpowder, phosphorus, and the air-pump, 31, 190
- Balm*, see *balsam*.
Balsam, what, 74 p. 93 p. 144, 145
 Its kinds, 144, 145 n
 Of *Peru*, its kinds, 144, 145 n
Capivi, its kinds, 145 n
 Whence, 94, 95, 144, 145 n
 All contain an acid volatile salt, 94 p. 96 p
 How changed into oils, 96 p
 Into rosins, *ib.*
 How affected by the sun's heat, *ib.*
 Dry, how analysed, 98 p
 Some totally volatile, *ib.*
 Of sulphur, how made, 271, 274 p
 Of metals, what, 271, 272 p
Balsamum sulphuris commune *ib.*
Terebinthinatum, 273 p
Anisatum, *ib.*
Barbadoes tar, what, 119
Barbusen, (*Job. Ceur.*) his writings characterized, 49 n
Bark of vegetables, what, 138 n
 Its offices and uses, 137 n
 Various juices thereof, *ib.* 145, 146. 74, 75 p
Barley, wherein it differs from malt, 110 p
Baulm, its water, 10, 41 p
 Virtue of its oil, 81 p
Becher, his character and writings, 52 n
Beer, what, 199
 Whether a wholesome drink, *ib.* n
 How made, 200 n
Bees, how they gather wax and honey, 142
Beguinus (*Job.*) his *Tyrocinium Chymicum* recommended, 46 & n
Bell-metal, of what composed, 92, 93 n. 98 n
Benjamin, virtues and uses of its tincture, 146 p
Bile, coagulated by alcohol, 329
 Naturally contains air, 430
 Its dissolving power, 566
Birch, virtues of its sap, 107 p
Birds, the reason of their not flying high in the atmosphere, 251
Bismuth, what, 132 & n
 Where found, *ib.*
 Artificial, how made, 132, 133 n
Bites, venomous how cured, 133 p
- Bisturn*, what, 106 n
Bitumen, what, 117 & n
 Its kinds, *ib.*
 Classified, *ib.*
 Where found, *ib.*
Judaicum, what, 118
Black bodies, why soonest heated, 262 & n
 Absorb fire, 554 n
 Return the light they receive, 263
Blea, or *bleak*, what, 138 n
Bleeding of trees, how practicable to advantage, 139 n
Block-tin, what, 99 n
Blood, what, 151
 The parts procured from it, 151, 152, 222, 223 p
 Coldest in the veins, 293
 Hottest in the arteries, *ib.*
 How distilled with safety, 487
 Holds much phlegm, 436 n
 To preserve it from putrefaction, 222 p
 Whether it contains any acid, 218 p
 How resolved, when coagulated, 219, 220 p
 How preservable, uncorrupted, 221 p
 That of pleuritic persons, how reducible to its natural state, 219 p
 Its spirit how gained, 223 p
 How it separates spontaneously, 217, 218 p
 237 p
 Its phenomena upon mixing with salts and oils, *ib.* 237, 238 p
 Coagulated by acids, but liquified by alkalies, *ib.*
 By what things thickened, and by what thinned, *ib.*
 See *Serum*.
- Blood-bounds*, whence they distinguish odours, 151
Bodies sensible, and insensible, 66
 Divided into three classes, 65 n. 66
 A simple body, what, 70 n
 Indifferent to motion or rest, 173 & n
 Their action, whence, *ib.*
 Their composition, 72 n. 158 n. 473 n
 Whence indestructible and unalterable, 158 n
 159, 160, 166 n
 Into what generally resolvable by chemistry, 158 n
 Some not resolvable by fire, 160 n
 How preserved from corruption, 95 p. 125 p
 133 p. 143, 144 p. 145 p. 182 p. 206 p
 221 p
 How analysed to discover their kingdom, 179 p
 Whence their difference, 168
 Not every where of the same size, 218
 Their percussions changed by heat, *ib.*
 Their laxity, what, *ib.*
 Their relative weight uncertain, 219
 Calcined, contain fire, 226 n
Bodins,

I N D E X.

Bodies, their parts in perpetual motion, 223
 Heated, have a constant oscillation, 287
 Heated by a friction in vacuo, 237
 Of different densities, why they heat and cool differently, 252
 Why dense bodies cool others soonest, 290
 Act on light, 252, 253 n
 Large bodies preserve their heat the longest, 257 n. 291, 292
 None naturally hotter than others, 297
 Which heat the slowest, *ib.*
 Of the least surface, most retentive of heat, 292
 What requisite to make them most tenacious of heat, 295
 The dense, heat slowly, 296
 Whence they prove less combustible, 330
 The small heat sooner than the great, 296
 Human, not destroyed by the fierce circulation of the blood, 16 p
 Hotter than the surrounding air, 248
Bohnius, his writings characterised, 56 n
Boiling, how liquors are affected therein, as to degree of heat, 374
 Heat, the greatest, liquors can receive, 233, 234
 Greater in proportion to the weight of the atmosphere, 234
Boles, what, 126, 128 n
 Their use in distillation, 254 p
Bolus, what, 184 n
Bolt-head, what, 584
 Its use, 584, 585
Bones, reduced to earth, again recoverable, 457
 Steeped in alkalies become firm, 518
 In acids, become soft, *ib.*
 How formed from milk, 188 p
 Yield no fixed alkali, 224, 225 p
 Abound in water, 225
 Afford a copious volatile salt, 224, 225 p
 Their composition, 226 p
 Yield not the animal principles, after long lying exposed, *ib.*
Borax, what kind of salt, 108, 109 n
 Native, and artificial, 109 n
 The artificial, how made, *ib.*
Pliny's account thereof, *ib.*
 Where found, 109 n. 559
 The factitious, only the native purified, 109 n
 Its properties, 108, 109
 Its uses, 109, 110
 Why called *chrysocola*, 109 n
 Its dissolving power, 559
 What it yields in distillation, *ib.*
 A flux for metals, *ib.*
 How refined, 109, 110 n
Borricius, his character and writings, 53 n
Boyle (Robert) his character, 55 n
 His writings characterised, 56 n

VOL. II.

Cleared from the imputation of credulity, 56 n
 His profuse encomium of certain remedies, whence, 56 n
Brandy, of what it consists, 123 p
 Whence its yellow colour, *ib.*
Brass, what, and how made, 93 n
Brewing, its origin and inventor, 199
 Directed by chemistry, 200
 The process of it, 199, 200 n
Bricks, whence their red colour, 95 n
 How made, 456
Brimstone, how made, 264, 265 p
 See *Sulphur*.
Burning-glass, its effects on gold and silver, 74, 75 n
 Its manner of acting, 263, 264
 Its action on metals explained, 101, 103 n
 Most forcible in winter, 268
 To augment its force, *ib.*
 Made of different matters, 264
 Of ice, 265, 465
Butler's-flame, of what composed, 92 n

C.

CABALA of the Jews, what, 9 n
Calcar, what, 184 n
Calcination, what, 280 p
 Whence it whitens bodies, 19 p
 By moisture, what, 277, 278 p
 Close calcination, what, 26 p
Calc, what, 280 p
 Of a metal, how reducible to a metalline form, 78 n. 85 n
 Of lead, how recoverable, 85 n
 Increased in weight by further calcination, 85 n
Camomile flowers, virtues of their water, 49 p
 Virtues of their oil, 81 p
Camphire, what, and how formed, 71 p. 154 p
Cancers, how cured, 38 p
Cases, old, why preferred to new, 109 p
Cathartics, what, and how they act, 29 p
Cathartic potions, what, and how made, 148, 149 p
 Their excellence, and manner of use, *ib.*
 How to diminish their force, 151 p
 Wherein their virtue resides, 151, 152 p
Causality, what, 100 n
Cautic, common, how prepared, 39 p
 Whence its force, *ib.*
 Attracts moisture, *ib.*
 Its uses, 39, 40 p
Celestial influences, owing to what, 269
 Bodies, whence their spherical figure, 292
Cements, of what composed, 191
Centurgle, his history and writings, 55 n
Ceruss, what, how made and used, 85 n. 285 p
 Its poisonous quality, 285 p
 H h h
Chalk,

I N D E X

- Chalk*, what, and whether a stone or earth, 127, 128 n
 Where found, 128 n
 In physical virtues, *ib.*
Chalcitis cum sulphure, how made, 284, 285 p
Characters, in chemistry, their origin and rationale, 67, 68, 69 & n
Charcoal, what, 307
 How made, *ib.*
 Its poisonous quality, *ib.*
 Transmuted by the alkali, 573
Chesse, what, and how made, 188 p
 Why sometimes rank, *ib.*
Chema, what, 8, 9 n. 11 & n
Chemia, what, 10 & n. 11 & n
Chemical pharmacy, its founder, 36 n
 Physic, its origin, 26
Chemistry, orthography, origin, &c. of its name, 7 & n. 8, 10, 11, 12
 Real antiquity of the name, 10
 What originally, 1 & n
 Origin of the art, 2, 8, 9 & n. 66 n
 Its history, 2 & n
 Its first traces, 12 n
 Revealed by dæmons, 8
 Its fabulous origin, 8 & n
 Why not treated of by *Latin* authors, 11 n
 Where first cultivated, 13 & n
 Why reputed a sacred art, 9 n. 11 n. 12 n
 Lost, and revived, 11 n
 An art, 66
 Definition of the art, 65 & n
 Division of the art, 12 n. 13 n
 A just theory of chemistry hitherto a desideratum, 2 n
 A just theory of chemistry, what, 3 n. 5 & n
Metallurgia, the most ancient part, 12
 First practised by *Tubal Cain* in *Egypt*, *ib.*
 Its practice how to be managed, 4 n
 Antiquity of its practice, 13 n
 Its different appellations, 11, 12 & n
 The authors therein, with their characters, 45 n. 46 n
 By whom applied to medicine, 31 n. 35 n
 46, 177, 178 n
 To philosophy, 52 n
 Dangerousness of its practice, 45 n. 46 n
 Best authors in chemistry, selected and classed, 46 & n
 Systematical writers, 46 & n. 61
 Writers on *metallurgia*, 49 & n. 61, &c.
 On alchemy, 53, 54, 62
 On the physical, and medicinal part, 55 & n.
 63
 Its object, what, 66
 Its effects, produced by motion, 155 & n
 Hints towards a rational account thereof, 155, 156 n
 Its operations, whereon depending, 155 n.
 156
 Reducible to two kinds, 156
 Its productions, 171
 Its ends and uses, 172, 173, &c.
 Wholly experimental, 172, 173
 Coincides with natural philosophy, 172, 173 & n
 Accounts for the composition of animal solids, and cohesion of fluids, 174, 175
 Its use in physiology, 174
 In pathology, 175
 In semeiotics, *ib.*
 In dietetics, 176
 In therapeutics, 177
 Censured by the faculty of *Paris*, 178 n
 Its use in painting, 178, 179
 In staining glass, 180 & n
 In enamelling, 179 & n
 In dying, 181, 182
 The art of glass, 182 & n. 183 & n
 Of gems, 185 & n. 186 & n
 Of metals, 188, 189
 Of war, 189, 190
 Its use in natural magic, 191, 192, 193, 194
 In working sham miracles, 194, 195
 In cookery, 197, 198
 Making wines, and other drinks, 198, 199
 In brewing, 199 & n. 200 & n
 In alchemy, 200, 201
 Its instruments, what, 205
 A course of operations therein, how to be conducted, 1, 2, &c. p
 Limitations of the art, 167, 168
Chemists, distinguished into three classes, 26 n
Chlorosis, a remedy for it, 49 p
 In virgins, whence, 189 p
Chrysolythos, what, 124 n
Chyle, what, and its origin, 148, 62, 63,
 64 p. 185, 186 p
 How made blood, 151
 Whether vegetable, or animal, 186 p
 How prepared in the body, 62 p
 Its difference from milk, 64 p
 Whence apt to turn acid, *ib.*
Chylification, how performed, 62-65 p
Cinnabar, native, what, and where found, 131 & n
 The marcasite of quicksilver, and reducible thereto, *ib.*
 The factitious, what, and how prepared, 131, 314 p
 Its virtues, and uses, 314 p
 Of antimony, how prepared, 331, 332 p
Cinnamon, its proportion of essential oil, 75 p
 Virtues of its oil, 76 p. 81 p
 Its oil turned to salt, 76 p
Circulation, what, 586
Circulatory vessel, what, *ib.*
 The manner of its use, *ib.*
Circulatum, majus, and *minus*, what, 578
Citronpeal water, 49 p
 Clari-

I N D E X

- Clarification, the several ways of effecting it,* 17 P
Clay, whether simple earth, 128 n
Classed, 129 n
Porcelain, a clay, *ib.*
Imitated, *ib.*
Its specific gravity, *ib.*
Clays, from what formed, 402
Acting as burning-glasses, 265, 270
Their figures, 270
What they contain, *ib.*
Their height, 402 & n
Cloves, Indian, sophisticated, before importation, 72, 73 P
Virtues of their oil, 73 P
Clyffus, what, 171
Congulation, how, and by what means produced, 338 P
Coal, what, and whence combustible, 307
Its blackness, whence, *ib.*
Wood-coal, what, 88 P
Coating of retorts, what, and how performed, 587
Cobalt, what, and where found, 116 n
Whereof composed, *ib.*
Its corrosive quality, *ib.*
Mother of arsenic, *ib.*
How treated for smalt, *ib.*
Cocoa-nut, how far reducible to oil, 63 P
Codion, its effects on vegetables, 47 P
Cohesion of bodies increased by cold, 222
Cobobating, what, 586, 48 P
Of distilled waters, how performed, 48 P
Its use, 49, 50 P
In what subjects performable to best advantage, 50 P
Colcothar, what, and how procured, 131 n
Cold, what, 219, 220 n
The intensest, which, 227
Whether its highest degree be assignable, 223
Contracts all bodies, 219, 222
Contraction, the measure of cold, 219
No absolute cold, 219, 246
Far exceeding that of ice, 228
When greatest, 227, 228
Effects thereof on the tops of the highest mountains, 234, 404
Producible from warm bodies, 351 n
Experiments about it by mixtures, *ib.*
Its ill effects, how prevented in the body, 95 P, 99 P
Proper to body, 219, 220
Colic, remedies for it, 68 P
Colophony, what, and how procured, 145, 146 n
74 P, 94 P, 96 P
Wherein it differs from rosin, 96 P
Its use in preserving insects, *ib.*
Its medicinal virtues, *ib.*
Colouring, of glass, and precious stones, by whom invented, 34 n
Colours of bodies, what, and whereon depending, 212 & n, 466
The heating and cooling, which, 264, 265
The chemical doctrine thereof, 341, 343 P
Their nature, production, changes, &c. *ib.*
How alterable by mixture, *ib.*
For painting, afforded by chemistry, 178, 179
Comets, use of their tails, 415 n
Concator, who, 184 n
Condensation, its ratio how found, 219
Constitution, the strongest, why seized with the severest diseases, 249
Contraction, the measure of cold, 219
Cookery, depends on chemistry, 197, 198
Copper, its nature, 68
Its chemical character explained, 68, 69 n
Its specific gravity, 70, 91 n
Ductility, 91
Extreme divisibility, 91 n
Fixedness, 91 & n
Difficulty and danger of its fusion, 91 & n
Easily dissoluble, by every salt, oil, &c. *ib.*
Different colours of its solutions, *ib.*
Its rust, what, *ib.*
Why called Venus, 91 n
Volatilized by lead and antimony, 91
Its elasticity and sound, 91 n
Varies its colour with the solvent, *ib.*
Why used for trumpets, 91 n
Its uses and medicinal virtues, what, and whence, 92, 93 n, 138, 139 P
The basis of the most famous remedies, 92 n
A quick emetic, *ib.*
Where found, and in what forms, 91, 92 n
Whence its high price, 92 n
Hard to purify, *ib.*
Blanched with arsenic, 116 n
Its tincture, what, 138 P
How dissolved and crystallized with vinegar and sal-ammoniac, 391, 392, 393 P
Virtues of such solution in spirit of sal-ammoniac, 393, 394 P
See Verdigrase.
Copperas, what, and how made, 131 n
Coral, a vegetable, 135 n
Its origin, and semen, *ib.*
Its flowers, seed, &c. *ib.*
Its analysis, *ib.*
Of various colours, *ib.*
Corn, how malted universally, 309, 310 P
Corrosive, its character, 68
Corruption, unintelligible without chemistry, 175
Cosmetics, the innocent, which, 146 P, 307 P
The dangerous, which, 287
Cosmetick, a good remedy therein, 29 P, 30 P
How remedied externally, 99 P
Cow, its character, and writings, 156 n
Cream of tartar, what, 26 P, 139 P
Crisis,

I N D E X

Crisis, by urine, mechanically explain'd 193 p
Cresu, why so called, 285 p
Aperius with sulphur, 284, 285
Astringens, how prepared, 279, 280
Metallum, how made, 328 p
 Its virtues and uses, 328, 329 p
Martis, its virtues and uses, 285 p
Crochus (*Ofwaldus*) his *Basilica Chymica*, characterised, 46 & n
Crucible, what, 583
 Its use, *ib.*
Crystal, described, 122
 How stain'd to imitate gems, 185 n. 187
 The manner of its formation explained, 126, 127 n
 How disposed for making gems, 185 n. 187
Crystal-Glass, how made, 184 n
 How disposed for making gems, 185 n
Crystal, *island*, how it affects the rays of light, 122 n
Crystallization, what, 449, 242 p
 How hinder'd, 24 p
 Its separating property, 242 p. 257 p
 How effected in metals, 277 p
Cucurbit, what, 584
 Its use, *ib.*
Cuogolo, what, 184 n
Cupels, of what earth best made, 308. 475.
 482. 19 p
Cupellation, explain'd, 71 n
 How it separates gold and silver, 85 n
Curmi, what, 199 n

D.

DEMONS, ancient and modern, doctrine thereof, 8. 9 & n
Decoctions, what, and how made, 13 p
 What parts of vegetables they contain, 14 p.
 83 p
 To make them rich, 14, 15, 16 p. 83 p
 Into what reducible, 14 p
 Wherein they differ from infusions and extracts, 15 p
 Vegetable-subjects best fitted for them, 14, 15 p
 Carry the virtues of simples into the blood, 15 p
 How clarified, 17 p
Destrua, what, and how made, *ib.*
 Nature and uses thereof, 17, 18 p
Delivery, to promote, 49 p
Density of bodies; from cold, 222
Deobstruents, what, and how they act, 28, 29 p
Desiderata, in chemistry; a vessel to hold the glass of lead in fusion, 86 n
 To clear silver of its adhering sulphur without loss, 88 n
 To facilitate the separation of copper from its ore, 92 n

To purge tin of its sulphur, 90 n
 To fuse crystal, 185 n
 A powerful attractive or dissolvent of sulphur or arsenic, 117 n
 To purge antimony of its sulphur, 132
 An innocent solvent for the stone in the bladder, 567, 568 & n
Dew, what, 401
Diamond, what, 182
 Why the chief of gems, 120 n
 Of what composed, 123 n
 Its specific gravity, 120 n
 How known for genuine, *ib.*
 Attractive, 121 n
 Its electricity how encreased, *ib.*
 Made lucid, *ib.*
 Its grain, 126 n
 Render'd denser by cold, 219
Digestion, *Animal*, explained, 182 p
 Chemical, rules for, 48 p. 50 p. 66 p
Diseases, whence produced; and when from acid, and when from alkaline causes, 189 p.
 218, 219 p. 221 p
 How judged of from milk, urine, &c. 189 p.
 190, 191 p
 Of women, remedies for them, 76 p
 Whence mortal, 201 p
 How they may arise from a bare stagnation of the fluids, 201, 202 p. 220, 221 p
 Inflammatory, how to be treated, 219, 220 p
 New ones; whence, 416 n
 Sailors, the best remedies for their diseases, 18 p
Distillation, what and how performed, 43, 44, 45 p. 54 p
 How to order the vessels concerned therein, 44, 45 p
 Subjects best fitted for it, 44 p
 How and when to be gather'd, and how prepared, 44 p
 What subjects are unfit for it, 44 p
 How perform'd upon fermented vegetables, 51, 52 p
 Effects of its being continued; 56 p.
 119 p
Per descensum, the manner of it, 54, 55 p
 Of inflammable spirit, 118, 119 p
 What parts of vegetables ascend therein, 46 p. 88 p
 Destroys not the fixed salt of the subject, 119 p
 Mischief arising from it by ill management, 46 p
 The physical knowledge it affords, 47 p
 How to be applied and regulated universally, 47 p
Distilled Waters, impregnated with the metal-line parts of the still; noxious, 46 p
 To remedy such ill effects, *ib.*
 Wherein their virtues reside, 47 p
Distilled

I N D E X.

Distilled Waters, their difference at different times of their running, *ib.*
 Their virtues, 47 p. 49, 50 p
Diuretics, what, and how they act, 29 p
Drops, medicines for it, 38 p. 49 p. 297 p
Drunkenness, what, 114 p
 Its effects, *ib.*
 How remedied and prevented, 133 p
 Allied to the apoplexy, 113 p
Dusility, accounted for, 72 n
Dying, depends on chemistry, 181, 182
 Its subjects how prepared, 201 p
 See *Scarlet Dys.*

E.

E*ARTH*, what, 126. 128 n. 473
 Of two kinds, 126 & n. 128 n
 Vulgar, defined, 128 n
 Whether a composition of sand and clay. 488
 Whether there be any simple or elementary earths, 128 n
 The basis of animals and vegetables, 153.
 482. 486. 20 p
 The basis of stones, 126 n
 How procurable pure, 153. 474
 Incapable of vitrification, 153. 485
 The same in all bodies, 153. 20 p
 Divided and classed, 126. 128 n
 The compound species, 128 n
 The sealed earth, 127. 129 n
 The chemical principle, what, 473
 Contained in air, 473 & n
 Of the fossil kingdom, 473
 Its fixedness, simplicity, &c. 473. 475
 How obtainable, 473, 474, 475, 476
 Afforded largely by vegetables, 474
 Obtainable from foot, *ib.*
 Whence obtainable from meteors, *ib.*
 Procurable from oils, 476. 480
 From alcohol, 474 n
 Afforded by animals, 479
 The same in animals as in vegetables, 481 & n.
 482
 Obtained from fixed alkali, 477
 Producing from fossils, 482, 483
 That obtained from water, not pure, 474 & n
 Whether contained in metals, 483, 484 & n.
 485
 Not the same with the calces of metals, 484 n
 Its uses in natural bodies, 486
 Its uses in chemistry, 487
 The basis of all chemical vessels, *ib.*
 Renders fixed salts volatile, 477, 478
 The grand instrument of fixedness and volatility, 480, 483
 Its use in distillations, 487
 A great attractive of oil, *ib.*
 Its use in purifying salts and spirits, *ib.*
 Virgin or philosophical, how procurable, 28 p

The Earth exposed to different degrees of heat, 222, 223
 Its figure from heat and cold, 221, 223
 Becomes uninhabitable from noxious vapours after earthquakes, 487 & n
Earthen Ware, of what made, 487
Earthquakes, whence, 497 n
 Artificial, producible by chemistry, 194
Efferescence, what and whence, 339, 340 p.
 467
 How produced, 339, 340 p
 Its kinds, &c. *ib.*
 The cold, hot and fiery, 340 p
 Requires water, 467
 Not found in the human body, 238 p
Effluvia may act without diminishing the weight of the body, 122
 Of vegetables, variously affect the body, 11 p
 See *Exhalations* and *Odores*.
Eggs, their yolk, what, 213 p
 White thereof, what, *ib.*
 Its office and use, 212, 213 p
 Forms all the parts of the animal, *ib.*
 How it appears to the senses, 212 p
 Is neither acid nor alkaline, 212, 213 p
 How affected by acids and alkalies, *ib.*
 Dissolves with a mild, but concretes with a stronger heat, 213 p
 How liquified and coagulated, 213, 214 p
 Concretes in alcohol, 214 p
 Distilled *per se*, 215 p
 Its water by distillation, neither acid nor alkali, *ib.*
 Solutive virtue thereof, 214 p
 Distilled, 215, 216 p
 Putrefied by digestion, 216, 217 p
 Is poisonous, 217 p
 Their yolk and white, consider'd as menstruums, 566. 214 p
 How hatched by incubation, 212 p
Egyptian Art, what, 12 n
Elæosacchara, how made, 100, 101 p
 Their uses, 101 p
 Their substitutes antiently, *ib.*
Elasticity, of two kinds, 250
Elements in Chemistry, what, 80 n. 158 n. 167
 Unchangeable, whence and why, 159, 217
 Their nature and office explained, 158 n
 Whence denominated, *ib.*
 A new definition thereof advanced, *ib.*
 The common doctrine thereof overthrown, 159 n
 Their number, 158 n. 159 n
 May be compound bodies, 159 n. 167
 Whence different in different subjects, 167
 Generally contain the medicinal virtues of bodies, 166 n
 In what order they rise from bodies, *ib.*
 See *Principles*.

Elixirs

I N D E X

- Elixir Proprietary*, its virtues and uses, 173 p
 How made to advantage, 174 p
 How made with distilled vinegar, 173 p
 How made by Paracelsus, *ib.*
 The notion of its great virtue whence, *ib.*
 How to be made an universal medicine, 174 p
 Prepared with alcohol and regenerated tartar, 176 p
 Made with fixed alcali, its virtues and uses, 174, 175 p
 How made with alcohol and fixed alcali, *ib.*
 Its virtues and uses with alcohol and fixed alcali, 175 p
 Made with spirit of wine and soluble tartar, *ib.*
Elixirs, what, 171
 How made with spirit of vinegar, 173 p
 With distilled waters and fixed alcali, 174 p
 With alcohol and fixed alcali, 174, 175 p
 With spirit of wine and soluble tartar, 175 p
 With alcohol and regenerated tartar, 176 p
Embalming, how practicable to advantage, 95 p. 125 p. 144 p. 173 p. 176 p
Emerald, what, 123 n
Emmenagogues, 49 p. 80 p
Emulsions, what, and how prepared, 61, 62 p
 How to be order'd, 62 p
 Their preparation analogous to that of the chyle.
Enamelling, by whom invented and treated of, 34 n
 What and how performed, 179 & n
 Its foundation, what, 86
Eni Veneris, what, 92 n
 How prepared, 320 p
 How run into a liquor, *ib.*
 Its virtues and uses, 321 p
Epilepsy, medicines for it, 49 p. 81 p. 302 p
Ercker (Laz.) his treatise on the *metallurgia*, 50 n
Exhalations, whence noxious, 417 n
 Of a compound nature, 410 n
 Corrosive and various, 410, 411 n
 Some wholesome, 416 n
Expansion, the criterion of fire, 213
 Its degrees measured, 215, 216
 Different in different bodies, 216
 In proportion to their weight, *ib.*
 Measure of heat, *ib.*
Experiments, dangerous in chemistry, 45, 46 n
 Succeed in certain places, and certain dispositions of the air, 417
 Instance of a fruitful or leaching one, 167 p
Extracts, what, 171, 17 p
 Their nature and uses, 17, 18 p
 How made, 17 p
 Two kinds thereof, *ib.*
 From what subjects best procurable, 14, 15 p. 18 p
Essential, what and how made, 152 p
 Their virtues and uses, 153 p
 More efficacious than their subjects, *ib.*
 With what caution to be used, 153 p
 Of saffron, how made, with its virtues, 152, 153 p
Eyes inflamed, a remedy for them, 104 p. 218 p

F.

Fainting-Fits, how prevented by vinegar, 133 p
Le Febvre, his treatise of chemistry characterized, 47 & n
Fennel, its distilled oil, 70, 71 p
Ferment, universal, what, 203
Fermentable Bodies, what, 106 p
 Classed with regard to their fermentation, 106—108 p
 In what proportion they require ferments, 141 p
Fermentation, its definition and cause, 52 p. 105 p
 Its difference from putrefaction, 105, 106 p
 How to be raised and conducted in all subjects, 52 p. 111—114 p
 Its requisites, 108 p
 Proceeds not *in vacuo*, 409
 How checked, 109 p. 114 p. 117, 118 p
 How raised and promoted, 52 p. 109 p. 114 p. 117 p
 Its phenomena, 52 p. 111—113 p
 The time it requires, 52 p. 114 p
 How known to be perfect, *ib.*
 Its surprising force, 112, 113 p
 Changes the oil of the subject into an ardent spirit, 53 p
 Lessens the virtues of the remaining subject, 53 p
 Greatly alters vegetables, *ib.*
 By attenuating the oils of vegetables, renders them undistinguishable, *ib.*
 Absolutely requisite to the production of inflammable spirit, 103 p
 Its difference according to the season, climate, &c. 52 p. 114 p
 The sole producer of inebriating liquor, 114 p
 Its poisonous nature, 113, 114 p
 May be spontaneous, 108 p. 111 p
 Into what parts it divides the liquor, 112, 113 p
 Not found in the human body, 105 p. 119, 120 p
Acetous, what, 130, 131 p
 How it proceeds, *ib.*
 Its ferments, or by what materials promoted, 130 p. 134 p
 How checked, 134 p
 Its effects, 132, 133 p
Ferments, what, 106 p
 Ferments,

I N D E X.

- Ferments*, the spontaneous or natural, which, 108, 109 p
 The heterogeneous, what, and how made artificially, 109 p
 Whether any in the body, 119, 120 p
 To what subjects, and how to be applied, 111, 112 p
Fertility of land, whence, 128 n. 461
Fever, only intelligible by chemistry, 202 p
 Enervate the body, 218
 Medicines for them, 211 p
Fire, what, 300
 Not fire, nor convertible into it, 301, 335, 366
 None burns of itself without fire, 331
 Not destroyed by burning, 335
 Whence carried off in ignition, *ib.*
 Oil, the only one, 305, 306. 313. 335. 336, 337. 341
 Different kinds thereof, vegetable, animal and fossil, 301, 336
 Other parts affected by the fire besides the oil, 312, 313
 Which the purest and best, 327. 330
Filtration, 17 p. 36 p
 How performed, 90, 91 p
Filter, 17 p. 90, 91 p
Fire, what, 236, 240 n
 Anciently held a Deity, 206
 Held uncreated, *ib.*
 By whom, and how first invented, 14 n
 Philosophers by fire, who so called, 206
 Its wonderful nature, *ib.*
 Its imperceptibility, *ib.*
 Its extreme minuteness, 206. 208
 Thought to be a spirit, and not a body, *ib.*
 Whether an original or generated thing, *ib.* n. 207 n. 366
 The universal instrument of nature, 206, 207
 Cause of all the motion and mutation in the universe, 206 & n
 Whether owing to motion, 206, 207 n
 Found in all bodies, 207 n. 209. 245. 270
 Concerned in every chemical operation, 206
 Procurable from all bodies, 207 n
 Whether diffused through all space, 338. 207 & n. 245, 246. 254. 276
 How we are to proceed in inquiring into its nature, 207
 Its mark or sign, 208, 209, 210
 Cause of fluidity, 209 n. 365. 437. 441
 Whether it be without light, 211
 May exist without heat and light, 210, 211, 212
 Its degree whether measurable by that of light, 212
 Its presence discovered by rarification, 213, 338
 Measurable thereby, *ib.* 214
 Its true criterion what, 214
 Expands all bodies, 213, 214. & 215 n. 216, 217. 338
 Experiments to shew its expanding power, 214
 Naturally unites with all bodies, 214 n
 Produces a repelling force in the particles of bodies, 215 n
 Changes and compounds, not barely separates bodies, 212
 Whether it fuses the elements of bodies, 217. 220 n. 362
 Acts on the very intimate nature of bodies, 218
 Strengthens some bodies, *ib.*
 The instrumental cause of all motion, 220 n
 Whether motion is essential to it, *ib.*
 Always in motion, *ib.* 246. 364. 365
 Produces its effects by motion, *ib.*
 Fixed in bodies, *ib.* 221 n
 Adds to the weight of a body, 220 n
 The only thing that affects the substance of bodies, 221
 Its degree always changing, 223
 Its quantity in any place how assignable, 224
 Expands air, but does not totally expel it, 225
 Changes the weight of mercury, 231
 Expands spirit of wine, *ib.*
 Its physical mark, 236
 How produced, 236, 237, 238 & n. 241, 242
 Penetrates all bodies, 237. 247. 366. 362
 Produced by friction, 237, 238 & n
 The intensest how produced, 242
 Its last degree by attrition not defineable, *ib.*
 Pure fire hardly to be found, 243
 Not discoverable without the action of solid bodies, 244. 276
 The alchemical and *Jerwish* notion of it, 244
 Its action, as generated by friction, 249
 Elastic bodies chiefly generate it, 250
 Its maximum and minimum, 251
 Vague and undetermined, *ib.*
 Encreased by other circumstances, 252
 Whether generated by attrition and percussion, 254
 Collected and moved by attrition and percussion, 254. 338
 Its recession spontaneous, 255
 Its proper conatus, *ib.*
 Its quantity and force, 255, 256
 Determined by the sun to a parallelism, 257, 258. 338
 The degree of fire by parallelism compared with that by attrition, 260
 Parallel fire collected to a focus, its effects, 266. 338
 Greatly encreased by parabolic specula, 266
 Its proportion in the catoptric focus difficult to assign, 273. 274. 275
 Its power, whether from quantity alone, 274
 A way of computing the force of it, 275, 276
 Fire,

I N D E X.

- Fire*, may be raised to any degree of force, 276
 Its highest effects by bare attrition, 277
 None greater than that in the focus of *Millette's Speculum*, *ib.*
 Its ultimate effect, what, *ib.* 375
 Its dioptrical production, 277
 Catoptrical, and dioptrical fire compared, 278
 Catoptrical, the strongest and closest, *ib.*
 The greatest dioptrical fire, which, *ib.*
 The effects of dioptrical, and catoptrical fires, 279, 280
 Dioptrical fire in the air, its effects, 280
 By collision, quicker and stronger than the dioptrical, 281
 The physical means of producing the most violent fire, 282
 Of great continuance without fuel, 283
 Expands itself equally from the centre of its mass, 283
 May be united, and fixed in bodies for a time, 284, 338
 And yet remain pure, 282, 283
 And without increasing weight, 285, 286
 Is loose and free in heated bodies, and in space, 286
 Strongest in the centre of the heated body, 286
 Its quantity hard to assign, 287
 Does not congregate with bodies, *ib.*
 Does not make bodies lighter, *ib.*
 The cause of its detention in bodies, 288
 Why quenched by water, 289
 The laws of nature with regard to fire, *ib.*
 Resides in bodies, in proportion to their bulk, 291
 Its fuel, 300, 335, 336
 Made to consume its own smoke, 309
 On what the power of vegetable fire depends, 314
 Elementary fire, what, 298, 338, 365
 Consists of the smallest particles, 359, 361
 How supported by its pabulum, 315
 Does not easily kindle the most inflammable bodies, 316
 The agreement betwixt fire and alcohol, 320
 Coagulates the animal fluids, *ib.*
 Greater in less combustible and ponderous fuel, 330, 331, 338
 Why strongest at a certain time, 332
 Why weak in alcohol, *ib.*
 Its power how heightened, *ib.*
 The physical manner of its acting, 333, 334
 Why it burns strongest in cold weather, 335
 Rarifies all bodies, 338
 Rarification, peculiar to it, *ib.*
 Its matter not supplied by the sun, 338
 Not generated *de novo*, 339
 Whether void of gravity, 339, 340 & n. 359
 Elementary, may be greatly increased, 341
 Its action on bodies, what, 341, 342
 How preserved, 341
 Whether corporeal, 357, 358, 361
 Collected by mixture, 342, 343, 344, 345, 346, 347, 348, 357
 Produced by the sole access of the air, 353
 Produced in iron filings and sulphur, 356
 Its ultimate elements very solid, smooth and simple, 361, 362, 363
 Its particles spherical, 362
 Always the same, 366
 The purest which, 367
 No universal solvent, 368, 369
 Does not separate bodies into their elementary parts, 370
 Compounds bodies, 370
 Its different degrees produce different effects, 370, 372
 Acts differently with respect to the air, 371
 How to be directed and used in chemistry, 372, 373
 Its several degrees and their uses, 373, 374
 Measured by the thermometer, 372
 How regulated for chemical uses, 375, 376
 Made to burn under water, 377
 Contained in air, 399
 In water, 437
 Its utmost effects in vitrification, 375
 Passes thro' the smallest orifice, and penetrates even gold, 360
 Is the most solid of bodies, 361
 The most polite, 362
 The simplest, and most similar of bodies, 362, 363
 May have different effects from the manner of its being blown, 368
 How increased by water, 354 n
 Its share in the action of menstrua, 493, 494
 Its power of destroying the virtues of vegetables, 32 p
 Of making acids, 254 p
Fire of suppression, what, 85 p
 See Light.
Firmness, in bodies, whence, 222
Fixedness, its meaning in chemistry, 74 n
 No body, fixed in nature, 320 p. 74 n
Flame, what, according to *Newton*, and *Hem-berg*, 310, 318, 327 n
 Not fire, 327 n
 Its kinds, *ib.*
 Whereof it consists, 318, 319, 323
 Its instantaneous production, 320
 Extinguished by oil, 222
 Increased by oil, *ib.*
 On what its power depends, 332
 The reason of its pyramidal figure, 335
 See Fire, and Heat.
Flowers, of vegetables, what, 141 & n
 Their office, 141 & n
 Their juices, 141, 142
 Flowers,

INDEX.

Flowers, their odour, whence, 91 p
 How best treated for their essential oil, 69, 70 p
 See *Vegetables*.
Fluids, the difficulty of ascertaining their rarefaction, 231, 232
 Heavier at the poles, than at the equator, 232
 Hinder the production of fire, 232
Flux albus, its remedies, 144 p
Flux, in metallurgy, 268
Focus, what, 266
Fetus, in the uterus, a vegetable, 150, 151 & n
Fossil, what, 66 & n
 Divided into simple and compound, 66 n
 The simple, which, *ib.*
 The Compound, which, *ib.*
 Classified, 67 n
 Their principles, 134 & n, 170 n
Fossil-salts, their principle, 113
 Their figures, 113 n
Fountain-salt, what, 105 & n
 How made, 105 n
Freezing, how effected, 227
 Point, difficult to observe, 228
Frit, what, 184 n
 Its kinds, *ib.*
Frost, artificial, how made, 227, 228
Fruit, to retard its growth, and preserve it on the tree, 137 n
 How prepared for fermentation, 111 p
Fulmination, explained, 71 n
Fuming of ores, what, 76 n
Furnaces, what, 588
 Their properties, and apparatus, 588, 589
 Perform a double office, 588
 Which the best, 588, 589
 Several kinds thereof, 589
 A simple one, 589, 590
 A portable one, 590, 591
Fusion fits metals to unite their separated parts, 218
 G.
GALL, considered as a menstruum, 566
Gangrenes, how stopped, 38 p, 40 p, 260 p
Geber, his history, writings, &c. 26 & n, 27
Gellies, what, and how made, 17 p
Gems, what, 120, 122
 Their origin, criterions, &c. 120, 121 n, 123, 126 n
 Divided into transparent, brilliant, and semitransparent, 120 n
 With regard to their colour, *ib.*
 Diamond, why the chief thereof, 120 n
 Their variety, whence, *ib.*
 Of what composed, 121 n, 122
 How formed in the earth, 121 n, 123 n
 How distinguished from their counterfeits, 120, 121 n
 Vol. II.

Their value, on what it depends, 123
 Their medicinal virtues, 121 n
 Naturally tinged with mineral juices, 121 n, 126 n
 The same kind have different colours, 126 n
 Their colours discharged, *ib.*
 Yield a tincture, 122 n
 Whether digestible in the body, 121, 122 n
 Whence transparent, and opaque, 126, 127 n
 Whence of determinate figures, 126 n
 Their texture and grain, whence, *ib.*
 Including foreign matters, 126 n, 127 n
 The art of making, or counterfeiting, what, 189 & n, 186 n
 Whence imperfect, 186, 187
 To counterfeit them in glass, 186, 187 n
 Best made from glass of lead, 186 n
General rules, caution in forming them, 76 n
Geoffroy, his history, and writings, 58, 59
Gilding with gold, the manner of it, 316 p
Glauber, his treatise of chemistry characterized, 47 & n
Glass, of what class it is, 182 n
Pliny's account of its being made malleable, 17
 The excellency of its art, 182
 Owing to chemistry, 182 & n, 183
 Its rise, and progress, 182 & n
 Never native, but factitious, 182 n
 Increased in weight by the fix'd salt, 183 n
 Salt, found therein in substance, *ib.*
 Its principal properties, *ib.*
 How it is made, 183, 184 n
 How blown, 184 n
 How fashioned, and made fit for use, *ib.*
 Whence green, 183
 Whence white, *ib.*
 Whence dissolvable by contained liquors, *ib.*
 How made of a sea-green, 187 n
 Of an emerald colour, 185 n
 Of a turcous colour, *ib.*
 Like jasper, *ib.*
 Of a gold yellow, *ib.*
 Of a granat colour, 186 n
 Of a sapphire colour, *ib.*
 Of a black colour, *ib.*
 Of a snow white colour, *ib.*
 Of a marble colour, *ib.*
 Of a deep red colour, *ib.*
 Of various colours, equal to gems, 185, 186 n
 Engraved stones, how copied therein, 187 n
 Has a kind of atmosphere, 238 n
 Corroded by the air, 183 n
 Of lead, how made, 186 n, 286 p, 289 p
 Its uses, 289 p, 292 p
Glauber, his character, and writings, 58 n
 His way of curing putrefied meats, 198
Gillard's drops, what, 226 p
 Gold,

INDEX.

- Gold**, its chemical character explained, 68 & n
 Its simplicity, and perfection, 68 & n, 70
 Its specific gravity immutable, 70 & n
 Its great porosity, 74 n
 Its malleability, 73, 73 n
 Impervious to light, and spirit of wine, 73 n
 Its immense ductility computed, with the cause thereof, 73 & n, 73 n
 Its divisibility, 72 & n, 73 n, 212, 490
 Is free from sulphur, 75 n
 In what proportion used to gild silver, 73 n
 Its fixedness in the fire, whence, 71 & n
 Rendered volatile with additions, 74, 75 n
Per se, 74 n
 Composed of what, 103
 Exposed to a burning glass, 74 n, 75 n
 What force of fire required to fuse it, 73
 Its solvents, 75 n
 Attractive of mercury, 74 & n
 Withstands both lead and antimony in cupellation, 71 n
 To try its purity, and reality, 70 n, 75 n
 Its found, whence, 73 n
 Supposed harder to destroy than make, 71, 573
 Destroyed, 71 n
 Philosophical, what, 71 n
 Found in three forms, but seldom pure, 75
 Its ore, and how dissolved therein, 71 n
 How separated from the ore, 76 & n, 77 n
 Found in a ruddy earth, 72 n
 How vitrifiable, 74 n
 Pure, how fitted for use, 188
 The several ways of making it, 203, 204
 Contained in all metals, 204
 How best made, 203
 Requisites to the making thereof, 202
 The art of making it, when first, and by whom pretended to, 16 n
 Made by *Caligula*, from orpiment, 17
 Composed of mercury and sulphur, 29 n, 101
 Re-convertible into running mercury, 101
 Extracted from sand, 50 n
 Contained in earth, salt, sulphur, &c. 50 n
 How separated from silver, 87 n
 Whence its colour and weight, 101
 Whether penetrable by mercury without increasing its bulk, 74 n
 Whether subject to rust, 74
 An enquiry into its medicinal virtue, 77, 78 n, 80
 Who first imagined it medicinal, 77, 78 n
 Purgative, whence, 77, 78 n
 Rendered potable by *Moses*, 74 & n
 Its sulphur, of no peculiar virtue, 77 n
 Dissolved by trituration, 454
 By spirit of snow water, 461
- By *aqua regia*, 387 p
 How alloyed with other metals, 78 n
 How separated from *am*, 78 n
 Its various preparations, 79, 80 n
Gold-dust, where found, 75 n
 Often adulterated by the negroes, 76 n
Golden-fleece, what, 17
Gonorrhoea, a remedy for it, 289 p
Gout, remedies for it, 338 p, 443 p
Gravity, specific, whether the criterion of metals, 70 n
Green-houses, how to be built, 260
Gualiacum, its analysis, 84, 85, 86 p
 The solutive power of its acid spirit, 348, 349
 Virtue of its rosin, 147 p
 How best treated by decoction, 14 p
 How treated to advantage by distillation, 54 p
Gum, what, 146
 Whence, 78 p
Gum-lac, what, 141 p
 To extract its tincture to advantage, 143 p
 Nature, and virtues of its tincture, 143, 144 p
Gummo-resin, what, 146
Gun-powder, by whom invented, 29 n, 190 & n
 A chemical production, 190 & n
 Its composition, 190 n
 How prepared, 190 n
 Its explosion accounted for, 190 n
 How rendered more powerful, 190 n
 The hint of its contrivance, 245 p
 Its fume, healthy in the plague, 267 p
- HAIL**, whence, 404, 405
Hay-stacks, whence fired spontaneously, 298
Heat, its nature, 206 n, 207 n, 210 & n, 230 n, 240 n
 Whether a mark of fire, 211
 And flame, from the mixture of cold bodies, whence, 197 & n
 Whether it be the same with motion, 206 n
 No measure of fire, 210, 211
 Expansion, its measure, 216
 Whereon it depends, 210 n
 What in the hot body, 190 n
 Whether producible by motion, 239 n
 Its requisites, 239, 240 n
 Its direction always, 239 n
 Defined by the Lord Bacon, 240 n
 Subterraneous, whence it may proceed, 251 n
 Independent of Light, 257 n
 Agitates all Bodies, 217
 And cold, their reciprocations useful, 222
Heat, produced by friction, 237, 238 & n
 Its mechanical production, 239 n
 From percussion, 233, 254
 Heat,

INDEX

- Heat**, produced by the undulation of elastic bodies, 254
Ceases, on altering the parallelism of the rays, 259, 260
On applying a cold dense body, 260
Its cause, on the earth, and in the air, 265
Of particular places, whence, 272
Bodies of least surface, most retentive thereof, 292
Different in men, whence, 292, 293
Where the greatest in the human body, 293
Of the air in respiration, 293
Its cause, 293
In mines, whence, 251 n
Produced by a mixture of cold bodies, 342, 343, &c. 349, 350, 351 n
How it may hinder dissolution, 493
In what degree prejudicial to the human body, 214 p
Coagulates the animal juices, 214 p, 220 p, 221 p, 237 p
A knowledge of its effects requisite to a physician, 214 p, 224 p, 217 p, 221 p
May cause surprising alterations in animal matters, 214 p
Cures effected by it, 219, 220 p
Helmst (J. B. Van.) his history, 41, &c. 44 n
His birth and education, 41, 42
Created doctor in physic, 43
Doubts the foundation of physic, 43
Commences chemist, ib.
His chemical discoveries, ib.
Turns all medicine into the vein of chemistry, 44 n
His writings, &c., 44 n, 55 n
His death, character, &c., 44
The judgment to be formed of him, 45 n
Not possess'd of the universal medicine, ib.
His *Archæus* explained, ib.
Failed in the cure of several diseases, 44
How he treated his own illness, ib.
His notion of the alkahest, 571, 576, 577, 578, 579
(Mercury) his character, 45 n
Hepar of Antimony, how made, 328
Hermes, held the inventor of chemistry, 8 n
Trismegistus, who, ib.
Hermatic art, what, 112 n
Hieroglyphics, the manner of writing 'em, 68 n
Heat-frost, indicates the instant of freezing, 229
Hoffman (Fred.) account of him, 60 & n
Hollandus (John and Isaac) their history, 34 & n
writings and inventions, 34 & n
Hamburg, his history, 56 n, 57
His character, and writings, 57, 58
His experiments, 59 n
Borrowed from Bacon, ib.
Hung, what, and how procured, 140 & n, 142
Contains iron, 140 n
Is kindled by its own heat, 140 n
Distilled before fermentation, 194 p
How prepared, 196
Hops, their medicinal virtues, 199 n
Why added to beer, 198
How, probably the same with *Palea*, 193 n
Hungary water, what, and how made, 158, 159
Hydragogues, 148 p
Hypochondriacal disorders, medicines good therein, 29 p, 49 p
Hysteric art, what, 12 & n
Hysterial disorders, remedies therein, 29 p, 49 p, 81 p

I.

JALAP, its tincture, how best extracted, 148 p
Its resin, whence more or less purgative, ib.
Jaundice, medicines for it, 38 p, 233 p
Ice, whence, and how produced, 209 n, 469, 437 n, 468
Lighter than water, 465
A menstruum, 465
In the air, forms *specula*, 280
The natural state of water, 465
How it bursts containing vessels, 468
Formed in the heavens, 464
Artificially produced, 227, 228
A kind of glass, 465
Jet, what and where found, 118 & n
Jewels, what, 114
Three kinds thereof, 120 n

See *Gem.*

Insects, what, 8 n
Incrustation of the ancient chemists, what, 40 p
Incubation, its use, 214
Indolence, its cause, 218
Infants, their peculiar disorders, how cured, 302 p
Inflammable matter, found no where pure, 314, 322
Influences of the celestial bodies, whence, 269
Infusions, what and how made, 13 p
What parts of vegetables they contain, ib.
How they differ from decoctions, 13, 14 p
The subjects best fitted for them, 14, 15 p
Carry the virtues of simples into the blood, 13 p

See *Decoctum*.

Inhabitants of hotter climates, softer and weaker, 218
Inks, their general basis, 278 p
Instruments of chemistry, what, 205, 280
Iron, its chemical character, 68, 69 n
Its nature, ib.
Its specific gravity, 70
Generated by art, 95 n
Afforded by all animal and vegetable ashes, 95 n, 282 p

I i i

INDEX

Iron, obtained from clay, and all other bodies,

Unites not with mercury, 81 & n. 83 n
 Its brittleness, whence, 93 n
 How made into steel, 96, 97 n
 How case-hardened, 96 n
 Its fixedness, 93 & n
 Very sulphureous, but capable of being deprived of its sulphur, 93 & n
 Hard of fusion, ib.
 Made ductile by ignition, 93 n. 96 n
 Increased in weight and bulk by ignition, 93 n. 214
 Its solubility, 93, 94 n
 Its rust, what, 94 n
 Changes colour according to the menstruum, 94 n
 Volatilizes with lead and antimony, 94 & n
 The only magnetical metal, 94
 How it gains a polarity, 94 n
 Whether the cause of the stone in the bladder, 95 n
 Where found, 94, 95 n
 In what form, ib.
 How worked from the mine, 95 n. 96 n
 Its ore various, ib.
 How tempered, when too brittle, 95 n
 In some countries preferred to the nobler metals, 95 n
 Its criterion, 94 & n
 Its medicinal virtues, 94 & n. 97 n
 Approaches a vegetable nature, 282 p
 How turned to vitriol, 277 p
 Given crude in some cases, 278 p
 Its tincture, or potable vitriol, how made, 278, 279 p
 Virtues and uses thereof, 279 p
 Its vitriol, how reduced to calx, 279, 280 p
 How run into oil, 280 p
 Valentine's golden tincture thereof, 281 p
 Virtues and uses thereof, ib.
 Its solution or tincture in *Rhenish* wine, how made, ib.
 With vinegar, 282 p
 Virtues and uses thereof, ib.
 Sublimed with sal-ammoniac, 283 p
 Its flowers how obtained, ib.
 Virtues and uses thereof, 283, 284 p
 A magnet with regard to acids and sulphur, 283 p. 284 p. 285 p. 325 p. 326, 327 p
 Destroyed by sulphur, 284, 285 p
 How calcined, 284, 285 p
Hand crystal, what, 122 n. 364 n
 How it affects the rays of light, ib.
Issues, how made by caustic, 38 p
Ich, how cured, 307 p
 Juices of plants, their difference, 5 p
 How clarified, 17 p
 Fluid and inspissated, how fitted for fermentation, 110, 111 p
Jugger, virtues of its oil, 81 p

Lead, obtained from clay, and all other bodies,

K *AL I*, what, 329
Kibes, how prevented, and cured, 99 p
Killing, how understood in chemistry, 335
Kingdoms, body justly divided into three, 65 n
Kunkel, his character, and writings, 53 n
L *AC Sulphuris*, how made, 269, 270 p
 Its virtues and uses, ib.
Lac Virginale, what, and how used, 146 p
 Metalline, what, and how made, 287 p
Lacca, for painters, how made, 179
Land, how rendered fertile, 128 n
Lapis atites, what, 124 n
Armenus, what, and where found, 133 & n
Hematites, what, and where found, 133 & n
 Its uses, ib.
 Whether it yields iron, ib.
 Its kinds, ib.
Infernalis, what, 369, 395 p
 How made, 295, 296 p
 Its effects and uses, 295, 296 p
Lazuli, what, and where found, 124 n. 133 n
 Distinguished from *Lapis Armenus*, 133 n
Stellatus, what, 123
Lawender, virtues of its oil, 81 p
Lavignan, what, 149 n
 Manner of its motion, ib.
Laxatives, 140 p. 165 p
Laxity, of bodies, what, 218
Lead, its chemical character, 68, 69 n
 Its nature, 69 n
 Nearly allied to silver, ib.
 Its specific gravity, 70. 84
 Two kinds thereof in chemistry, 71 n
 The chemical names for it, ib.
 Whence called *Saturn*, 85
 Its use in cupellation, 71 n. 85 n
 Turns to glass therein, 85 n
 Suspends all bodies, but gold, and mercury, 84 n
 Approaches to, and yields mercury, 84 n
 Mixes only with mercurial metals, ib.
 Its softness, 84 & n
 Refines of fusion, 287 p
 Incapable of ignition, 84
 Its distinguishing properties, 84 & n. 85 & n
 Its penetrative and dissolving nature, ib.
 Retolvable into scoria and mercury, 84, 85 n
 Readily vitrified, 85 n
 Easily recovered from its calx, ib.
 Dissolves sweet in weak acids, 85 & n. 289 p
 Its use in obtaining, and separating gold and silver, 85 n
Lead,

I N D E X

- Lead*, volatilizes every thing but gold and silver, 85 n
As solvents, *ib.*
Absorbs metals, 85
Its found, 84 & n
Unclastic, *ib.*
Allied to and converted into gold, 84 n
In what forms found, 85, 86 n
How gain'd from its ore, 86 n
How calcined, 286 p
Increased in weight by calcination, 85 n. 286 p
Dissolved and turned to ceruse by vinegar, 85 n. 285 p
In oil, 523
Poisonous quality thereof, 85 n. 286 p. 293 p
Its solution in distilled vinegar, 287 p
How turned to oil, *ib.*
Virtues and uses thereof, *ib.*
Its vitriol, how procured with distilled vinegar, 288 p
Its incrated oils, what, 289 p
Its vitriol with aqua fortis, *ib.*
Virtues and uses of its vitriol with aqua fortis, 289 p
Its balsam with oil of turpentine, 291, 292 p
Its conversion into glass, 292 p
Leaves of plants, what, 140
Their nature and office, *ib.*
Their juices, *ib.*
Less, what, 113 p
Lemery (the elder,) his history, 48 n
His course of chemistry characterised, 47 n
Lengthening Vessels, what, 585
Lewis XIV. an instance of his generosity, 191 n
Life, by what means lengthen'd, 144 p
Light, whether original, or producible, 206 n
Its universality, 207 n
Whether a Mark of fire, 211
Its matter diffused among terrestrial bodies, 313 n
A single ray divisible into seven others of different colours, &c., 363 & n
Its motion rectilinear, 257, 258
Produced from bodies sensibly cold, 356, 357
Fixed and detained in bodies, 101
Its share in the composition of metals, *ib.*
A hard and solid body, 361
Affected by bodies at a distance, 364 n
Independent of heat, 211
How obtained by friction from glass, 238 n
Passes uninterrupted through all bodies, 360
The sides of its rays have different powers, 363
Its phenomena in passing through island crystal, 363, 364 n
Differently refrangible and reflexible, 363 & n
Its reflexion, whence, 364 n
Its fits of easy reflexion and transmission, *ib.*
How affected in passing through different mediums, *ib.*
Its velocity, 365
See Sulphur and Fire.
Lightning imitated by chemistry, 190
Lime, its effects in the body, 197, 198 n
In what cases to be used medicinally, 198 p
Why pernicious in hot, but serviceable in chronic diseases in cold climates and constitutions, 198 p
Contains much fire and water, 220 n
See Quickfilver.
Liquors, the effect of mixing hot and cold liquors together, 290, 291
Lifter (Martin) his notion of the stone's being producible from iron taken in with the food, 95 n
Litharge of gold and silver, what, 286 p
Its kinds, &c., *ib.*
Lithantbrax, what, 118 & n
Lixivium, alkaline, how made violently strong, 39 p
Loadstone, what and where found, 133 & n
Its effects mimick'd by iron, 94 n
Affords iron, 95 n. 134 n
Effects of its effluvia, 121 n
How weaken'd, 134 n
Lobsters, their shells, how form'd, 151 n
Long-necks, chemical, what, and their use, 583, 584
Lullian art, what, 32 n
Lully (Raymund) his history, 32 & n
Introduced the transcendental art, 32 n
His writings and discoveries, 33
His travels and fate, 33 n
Luda Cornua, how made, 299, 300 p
How reduced to silver again, *ib.*
Lunar Caustic, how made, 295 n
Lutes, what, 586
Their use, *ib.*
The common, how made, 586, 587
For aqueous and sulphureous liquors, 586
For acetous liquors, 586, 587
For fossil acids, and volatile alcalies, 587
In what cases used, 586, 587
Excellence thereof, *ib.*
The philosophical, of what composed, 587
Its manner of use, &c., *ib.*
Substitutes for it in some cases, 587
For coating of retorts, *ib.*
- M.
- MAD Dog, the bite how cured*, 133 p
Magic, what, 29 n. 192, 193
How practicable by chemistry, 194, 195, 196
Magistery, what, 171
Magnetism of iron, 94 n
Malleability, accounted for, 72 n
Malt, how made, 199, 200 n
Distilled before fermentation, 103 p
How treated in the cough, 200 n. 110 p.
Mals,

I N D E X.

- Malt*, its difference from corn or barley, 119 p
 To check its two violent fermentations, *ib.*
Malt-Liquors are wines, 114 p. 121 p
 How made to afford most spirit, 114 p. 118 p
Malt-spirit, whence its foulness, 118 p
 With what cautions to be distilled, 118, 119 p
Malting, what, 103, 104 p
 Its rationale, 109, 119 p
 Its perfection, wherein it consists, 110 p
Manganese, what, 184 n
 Its use in glass-making, *ib.*
Manna, what and whence, 107 p
Marls, what, 127, 129 n
Matrasses, what, 584
Matter, what, 220 n
 How originally fashioned, 473 n
 Whence unchangeable, *ib.*
 See *Body and Element*.
Matthew's Pill, what, 164 p
Maxy, what, 99 n
Mead, what and how made, 121 p
Mechanics, what, 178 & n
 Their use in solving chemical phenomena, 155 & n
 Divided into rational and practical, 178 n
Medicated Liquors, how prepared, 101, 102 p
 Their uses, 102 p
 How to be administer'd, *ib.*
Medicinal Chemistry, authors in it, 35, &c.
Medicine, improved by chemistry, 35 & n.
 37 n. 174, &c.
Medicines, portable, how procured, 17, 18 p
Melenteria, what, 130
Mémairs of the R. Academy, the chemical pieces therein, 56, 57, 58, 59 & n
Menstruum peracutum, what, 75 n
 Its power, *ib.*
Menstruums, what, 489
 Manner of their action, 489, 492, 493, 494, 497, 498
 Four conditions requisite to their acting 507, 508, 509
 Seldom act mechanically, 496, 497
 Act mechanically, and in what sense, 490, 496, 497, 506, 511
 Are dissolved in the act of solution, 489, 496
 Origin of the name, 489
 Act by motion, 495, 496
 The knowledge thereof important, 489
 Divided into solid and fluid, 490—494
 The solid, which, 490, 491
 Divided according to their manner of dissolving, 497—499
 Metals are menstruums to one another, 490
 Act not in a dry form, 490, 504
 Dry ones, how brought to act, 490
 The liquid or fluid, which, 491, 492
 The acid, which, 546—555
 The aqueous, which, 550—552
 The oleaginous, which, 550—552
 The alkaline, spirituous, which, 528
 The acid spirituous, *ib.*
 The inflammable, 526, 527
 The fixed alkaline, 529—547
 The compound saline, 559—562
 The simple saline, 528, 529
 Variously compounded and diversified, 559, 560, 561, 562, 563
 An innocent one for the human calculus discoverable, 567, 568
 Some have an internal principle of motion, 565
 Some made to act by external force, *ib.*
 Must be appropriated to the solvend, 493
 Must have a secret relation to the bodies they dissolve, 493, 567
 Why all cannot dissolve all bodies, 567
 Dissolve not always the better for being stronger, 566, 568
 Their action depends principally on fire, 493, 494, 515, 564
 May have their action obstructed by heat, 493, 515
 Their actions never determinable *a priori*, 498, 568
 Their action reciprocal, 568
 Not regulated by the hardness or softness of the solvend, 506, 567
 The acid dissolve not equally, 554
 The spirituous have their peculiar subjects, 527
 Some to be used preparatory to others, 565
 To determine the subjects for the aqueous, 515—517
 For the sulphureous and oily, 526
 For the inflammable, 527
 For the alkaline, 545
 For the acid, 553
 May be innocent, yet powerful, 568
 A new set, how procurable, 563, 564
 The strongest, not required for the hardest subjects, 567
 An uncommon one from rye bread, 568
 A mild one effecting extraordinary solutions, 566
 The change between them and the solvents generally reciprocal, 493, 493
 Their strength sometimes impaired by rectification, 568
 Some must be exquisitely purified to make them act, *ib.*
 If an universal one be obtainable from sea-salt, 580
 How to be suited to the extracting of tinctures, 148 p
Mercurius Fite, how made, 333, 334 p
Mercury, what, and whether it be a metal, 67
 What, according to *Becher*, 580
Mercury.

INDEX

- Air**, the basis of all metals, 39 n. 82.
 101 n. 134 n.
Penetrating gold, 74 & n.
 Its use in separating gold, 76 n.
The true solvent of metals, 315 p.
 Its gravity, 70, 80 & n.
 Its weight changed by fire, 234.
 Its purity and simplicity, 80 & n.
 Its three different states, 81 n.
Virgin, what, 83 & n.
 Its kinds, 82 & n. 83 n.
 How purified, 83 n.
Of the philosophers, what, 80 n.
 Procured from lead, 84 n.
 How it dissolves gold, 101 n.
 How turned into gold and silver, 102 n.
 Fixed by the fumes of lead, *ib.*
 The principle, what, 158 n.
 See *Quicksilver*.
- Mercury of Metals**, 204 & n.
Metallurgia, what, 49 n. 188.
 Writers therein, 49 & n.
 Chiefly practised among the Egyptians, 15 & n.
 Its antiquity, 12, 13 n.
 Its inventor, *ib.*
 Difficulty of the art, 12 & n.
- Metals**, of what they consist, 55 n.
 Their definition, division, &c. 67 & n.
 Their apotheosis, or similitudes with the heavenly Bodies, 67.
 Their scale, or characters, 67, 68 n.
 Their distinguishing property, 67 n. 69.
 101 n. 103.
 Specific gravity, 70 & n.
 No certain criterion of metals, 70 n.
 Their origin and formation, 67 n.
 Whether coeval with the world, *ib.*
 How produced in the earth, *ib.*
 Which of them are fixed, and whence, 73 n.
 The imperfect abound with sulphur, *ib.*
 How purged of their adhering sulphur, 268 p. 270 p.
 How expelled, 71 n.
 Their affinity in fusion, 104.
 The perfect, what, 80, 81 n. 102 n.
 Imperfect, what, 102 n.
 The general doctrine thereof, 101 n.
 Composed of sulphur and mercury, *ib.*
 Their analysis, 101 n. 103 & n.
 Their principles, *ib.* *ib.*
 The difficulty of making them, 103.
 The properties easiest changed therein, *ib.*
 How malleable, 268 p.
 The impure, of what composed, 103.
 No new metals procurable by art, 104.
 Soluble in water, 277, 278 p.
 Our knowledge of them imperfect, 104 n.
 The best menstrua for each other, 490.
 Their action, whence, 312 p.
 Their nature varied with the salts joined with them, *ib.*
- How render'd potable universally, 278 p.
 Their particles attract one another in fusion, 218.
 How reducible to powder, and recovered into metal, 490, 279, 280 p.
 How run into oils, 267 p. 283 p.
 How convertible to flowers universally, 283 p.
 Quicken'd and made active by sublimation, *ib.*
 Are attractive of acids, 287 p.
 Their different tastes in solution, *ib.*
 How convertible to balsam, 291 p.
 How reducible to glass, 292 p.
 How purified, universally, by amalgamation and lotion, 315, 316 p.
 What they deposite by lotion, 316 p.
 How render'd volatile, or turned to a butter, 333 p.
 How made poisonous, *ib.*
 Made volatile by sal-ammoniac, 555.
 Their red tincture, what, 269, 270 p.
Meteors, whence and what, 263, 495.
 Fiery, whence, 265.
Mespeglin, what and how made, 121 p.
Milk, what, 62 p. 183 p.
 Its origin in the body, 62 p. 64 p. 185 p.
 Generated in men as well as women, 185 p.
 Whence apt to turn acid, 64 p. 199, 200 p.
 How it commences animal, 64 p.
 Its nature, parts, kinds, &c. 185 p.
 Differs in goodness with the animal that sords it, 186 p.
 Shew'd to be neither acid nor alkali, 186 p.
 A kind of emulsion, 186 p. 199 p.
 Sign of its putrefying, 200 p.
 From what animals, and on what occasions apt to putrefy, *ib.*
 Strongly coagulated with acids, 186, 187 p.
 How made into cheese, 188 p.
 Its natural colour white universally, 186 p.
 Disposed to turn red, 188, 189 p.
 Turn'd red by boiling with alkalies, *ib.*
 Whence morbid, 189 p.
 Of nurses, &c. how affected by a fever, *ib.*
 How alter'd by an alkaline disposition of the body, *ib.*
 Readily convertible into blood, 186 p.
 Virgin's milk, what, 146 p. 149 p.
- Minerals**, defined, 66 & n.
 How formed in the earth, 67 n.
 Their growth from water, 447 n.
 See *Fossil*.
- Mineral-Waters**, whence, 462 & n.
 May be copiously diluted with rain, 462 n.
Miners, how affected in the quicksilver works, 83 n.
 In the silver mines, with a preservative for the same, 88, 89 n.
 How they live in the salt mines of *Wit-litsa*, 105 n.
Mines,

I N D E X.

- Mine* of gold, how work'd, 75, 76 n
Gold-mine of *Crimnitz*, 76 n
Of quicksilver, how work'd, 82, 83 n
Of lead, how work'd, 85 n
Of silver, where found, 88 & n
Exhalations poisonous, 88 n
Of Potash, 89 n
Of copper, how work'd, 91 & n
Of iron, where found and how wrought, 94, 95 & n
Of tin, how wrought, 105 n
Of salt, how wrought, 105 n
The heat found therein, whence, 251 n
Minium, what, 85 n
How made, 286 p
Wherein it differs from *litharge*, *ib.*
Its virtues and uses, *ib.*
Of the ancients, what, 131
Mint, virtues of its oil, 81 p
Mint-water, cohobated, its virtues, 49 p
Miracles, performable by chemistry, 194, 195
Mirrors made of wood, 264
Of straw, *ib.*
See *Burning-glass*.
Moon-light, collected without heat, 211, 268
Morinus, his character and writings, 27 & n
Le Mort, his chemical writings characteri-
sed, 48 n
Mortifications, how stopped, 38 p
Mother of nitre, what, 108 n
Of wine, what, 113 p
Motion, what, and how requisite to action, 155, 156 n
Its effects, what, 156 n
Produced by gravity and attraction, *ib.*
Whether essential to fire, 220
See *Fire*.
Mountains, their use, 403
Mullum, what, 104 p
Its virtues, *ib.*
Its distilled water, *ib.*
Mundic, what, 99 n
How clear'd from its ore, 100 n
Mussels, their anomalous nature, 148, 149 n
Differ greatly from other animals, *ib.*
Generate within themselves, *ib.*
Their manner of walking, *ib.*
Their arms, *ib.*
Growth of their shells, 149, 150 n
Pond-Mussel, manner of its creeping, 149 n
Sea-Mussel, manner of its motion, *ib.*
Mussel, what, 17 p
Myrrh, its tincture, how best made, 144 p
Virtues and uses thereof, *ib.*
Soluble with the white of an egg, 566
N.
N *APHTHA*, what and where found, 117 & n
Pewee of fire, 336
Resembles alcohol, 336
Its inflammability, 117 & n, 336
Differs from *Oleum terræ*, 117 & n
Natural Philosophy, what, 172
Its parts, *ib.*
Its office, *ib.*
Neutral salts, what, 555
Their dissolving powers, 555, 564
Nitre, its properties, 197 & n
A natural salt, and how procured, 107, 108 n
How purified, 109 n
Its origin and history, 107, 240 p
Whether the ancient were the same with
ours, 240 p
Whence the modern is all obtained, 108 n
Whether fossil, animal, or vegetable, *ib.*
Producible by art, *ib.*
Its virtues and uses, 109 n
To prevent its fusion, 254 p
Neither alkaline, nor acid, 240 p
How render'd inflammable, 240 p, 243 p
Is not naturally inflammable, 240 p
Its medicinal virtue, 240, 241, 242 p
Easily fusible, 240 p
How purified by crystallization, 241 p
How converted into fixed alkali with tar-
tar, 242, 243 p
Alcalized nitre, what, 244
Its dissolving power, 557, 558
A flux for metals, 557
How made into fixed alkali with char-
coal, 534, 243, 244 p
Made into *sal prunella*, 245 p
Into *sal polychrestus*, 245, 246 p
Its spirit, with bole, how made, &c. 253, 254 p
How render'd totally volatile, or converted
into acid spirit, 254 p
Glauber's spirit thereof, how made, &c. 247 p
Convertible, both into acid and alkali, *ib.*
How regenerated fix'd, from its spirit, 249, 250 p
Semi-volatile, with *sal-ammoniac*, 251 p
How made acid, or impregnated with its
own spirit, *ib.*
Vegetative, how made, 252, 253 p
Nitrum Antimoniatum, how made, 330 p
Its nature and uses, *ib.*
Nitratum, what and how made, 252 p
Its uses, *ib.*
O.
O *culus Mundi*, alterable by water, 122 n
Odeurs, owing to water, 466
Their influence on the body, 111 p
The chemical doctrine thereof, 341 p
Offa

I N D E X.

Ossa alba, its nature, virtues, and uses, 232,
 233 p
 How made, 232 p
Oil, of what composed, 370
 Its use in the composition of bodies, 30 p
 Its expansion measured, 23 n
 Its use in the seeds of vegetables, 143, 58 p
 In wood, 144
 Its embalming, and preserving virtue, 145,
 522, 523
 Its flame stronger, as it is heavier and
 thicker, 324, 325
 The reason of its soaking through casks, 442
 Vegetable, what, 144, 145
 Its kinds, 57, 58 p
 Animal, its nature and character, 228, 229 p
 But one in nature, 229 p
 Its origin in vegetables and animals, 62 p
 Procurable in large quantities from vege-
 tables by coction, 14 p
 Of almonds, its virtues and uses, 60, 61 p
 Of mustard-seed, its virtues, 60 p
 Of earth, what, 119
 The onlyewel, 305, 306, 335, 336, 20 p
 Its tenacity and branchy nature, 57 p
 How affected, and at length consumed by
 fire, 306
 Whence differently inflammable, *ib.*
 Of sulphur *per campanam*, why best made
 in a moist air, 266
 Its nature, virtues, and uses, 267, 268 p
 Resembles oil of vitriol, 267 p
 How made, 266, 267 p
 Of tartar *per deliquium*, what, 142 p
 Of turpentine, turned to rosin, 94 p, 96 p
 How fitted for preserving anatomical pre-
 parations, 95, 96 p
 Its effects when taken too freely, 95 p
 Æthereal, whence called, 93 p
 Its virtues and uses, 93 p, 95 p
 How distilled to advantage, 93, 94 p
 Of vitriol, how made, 318, 319 p
 Volatilizes fossil salts, 247
 How dulcified, 275, 276 p
Oil, whereof they consist, 524, 82 p
 Are a fluid camphire, 71 p
 Repel water, 458
 Act by means of their water and acid, 324
 Extinguish fire, 306, 316
 Hold much fire, 521, 522
 Convertible to earth and water, 370, 81, 82 p
 Not obtainable pure, 524
 Their solutive power, whence, *ib.*
 Vegetable, what, 20 p, 57 p
 How made inflammable spirits, 53, 54 p
 Acid and impure, 524, 525
 Whether the pure will dissolve metals, 325
 Whence they rust iron, *ib.*
 How gained by expression, 520
 Distilled, how gained and purged, 524
 Vol. II.

The solvents of sulphureous matters, 426
 How separated from the other principles,
 and preserved, 90, 91 p
 How they lose of their force, 91 p
 Grow thick by age, heat, &c., 57 p, 91 p
 How reduced into elæosacchara, 100, 101 p
 Whether dissolvable in pure alcohol, 135 p
 How adulterated, 92 p, 156 p
 Their adulteration, how discovered, *ib.*
 Essential, what, and why so called, 66 p
 Contain the native spirit of the vege-
 tables, 54 p, 56 p, 66 p
 Gained from the leaves of plants, 65 p
 Where and in what forms found, 58 p
 Visible in the subject, *ib.*
 How procured native by expression, 59, 60 p
 Their nature and uses, 60, 61 p
 Are apt to grow rancid and caustic, 60 p
 With what caution to be prescribed, 61 p
 How obtained by emulsion, 61, 62 p
 Nature and use thereof, 62, 63 p
 How changed milky, 61, 62 p
 How advantageously procured by cocti-
 on, 63 p
 Their nature, 63 p
 Subjects proper to be distilled for essential
 oil, 65 p
 To increase their quantity in distilla-
 tion, 66 p, 69 p
 Those of *Europe* float, but those of *Asia* and
America sink in water, 73 p
 Their colours different, 79 p
 How purified, 81 p
 Lose by rectification, *ib.*
 Reducible to a waxy substance, 57 p
 Resolvable into four parts by water, 81 p
 Into what resolvable by distillation with ad-
 dition, 82 p
 Their properties, medicinal uses, &c., 167,
 68 p
 In what distempers proper, 67 p
 How distilled from flowers, 69 p
 From seeds and berries, 70, 71 p
 To prevent their clogging the worm in di-
 stillation, 71 p
 How procured native from the *Indian* spi-
 ces, 72, 73 p
 Are richest in the hottest countries, 73 p
 How known to be adulterated, *ib.*
 How distilled from barks, 75, 76 p
 From woods, 73, 74 p
 How distilled native, *per descensum*, 77 p
 Their aromatic virtue, what, and wherein
 it consists, 77, 78 p
 Why more aromatic than the expressed, 78 p
 Animal, convertible into earth, 228, 229 p
 Are the same with those of vege-
 tables, 229 p
Oler, what, 133
 Contained in *Spaw*-waters, *ib.*
 K k k *Oker*,

I N D E X.

- Oleum*, found magnetical, 94 n
 Rich in iron, 129 n
Oleum Martis per Deliquium, how made, 280 p
 Its virtues, *ib.*
Oleum Terra, what, 119
Oryx, what, 124 n
Opal, what, *ib.*
Operations in chemistry, what, 155. 3 p
 Their simplicity, 157
 Their kinds, 157, 158
 Their effects, 158. 167
 Require the assistance of air, 434
 How varied by the air, *ib.*
 Frequent reasons of their failure, 416, 417.
 Their object, 435
Opium, its tincture, 148 p
Ore of Copper, where found richest, 91 & n
 How work'd, 92 n
 Of gold, 75 & n
 How work'd for the metal, 76, 77 & n
 Of iron, what, and how treated, 94, 95,
 96 n
 Which the best, 95 n
 Of lead, 85 & n
 Poisonous to brutes and other ani-
 mals, 85 & n
 Of different kinds, 86 n
 Lead-ores classed, *ib.*
 Afford silver, but not in proportion to the
 lead, *ib.*
 Of mercury, 82 & n
 Of tin, proving rich in silver, 99 n
 How wrought, 99 & n
 Of silver, 88, 89 & n. 90 n
 How wrought, 89, 90 & n
 How work'd in *Peru* and *Chili*, 88 n
Ores, what, 123
 How treated by torrefaction, coction, amal-
 gamation, lotion, fusion, distillation, and
 solution, for their metals, 76, 77 n
 How clear'd of their sulphur, &c. 268 p.
 270, 271 p. 323, 324, 325 p. 327 p
 Rationale of their purification by the
 flux, 324, 325 p. 327 p
Orpiment, what, and where found, 115 & n
 Contains gold, 17
 Its uses, 115 n
P
Painting, what, 178
 Depends upon chemistry, *ib.*
 In glass, what, and how perform'd, 180 & n.
 The colours for it, how made, 180 n
Paracelsus, his history, 37 & n
 His education, 37
 Travels, *ib.*
 Made professor of physic and philosophy at
Basel, 38 & n
 Burns the books of *Galen* and *Avicenna*, 38
 Takes to drinking, 39
 Relinquishes his professorship, *ib.*
 Manner of his death, 39
 Was an eunuch, 37
 His writings, 40 & n
 His real merits, what; and whence his great
 name, 41, 42 n
 Knew the use and virtues of opium, 38. 41 n
 Had not the universal medicine, nor the
 philosopher's stone, 41 n
 How he speaks of the alkahest, *ib.* 570
Paraguay, the herb, its preservative vir-
 tue, 89 n
Pathology, how improved by chemistry, 175
Pear, what, 367 n
 Where found, *ib.*
 Charr'd in *Holland*, *ib.*
Pelican, what, 586
 Its use, &c. *ib.*
Pendulums, lengthen in the torrid zone, 218
 Their oscillations slower in the torrid
 zone, *ib.*
 Shorten in the frigid zone, 221
 Their vibrations quicker in the frigid
 zone, 221, 222
 Vibrate equally in hot and cold wa-
 ter, 442
Perfumes, to recover their lost odour, 142 p
 To increase their virtues, *ib.*
Perspiration, insensible, the matter thereof in
 animals, 151
Petroleum, what and where found, 117
 Differs from naphtha, 117. 336
 Fewel of fire, 336
Phial, what, 584
Philalethes, a modern author in alchemy, 54 n
Philosophers by fire, who, 12 n. 20
Philosopher's Stone, what, 26, 203
 The notion explain'd, 203
 Antiquity of the notion, 15, 16 n
 Unknown and unheard of among the an-
 cients, *ib.* & 17 n
 By whom first mentioned, 17, 18
 Whether couched in the fables of the *Ar-
 gonauts*, &c. 17
 The notion countenanced by *Hollandus*, 34 n
 Whether obtainable, *ib.*
 Whether known to *Paracelsus*, 38
 Its character and effects, 203
 Criterion of its reality, 204
Philosophical Transactions, the chemical pieces
 therein characterised, 56 & n
Phlogon, what, 161 n
 Whether obtainable pure, *ib.*
 Of vitriol, its virtues, *ib.*
 Whence obtainable to largely from some
 bodies, 162 n
 See *Water*.
Phosphori, what, and how made, 358 & n
Phosphori,

INDEX

- Phosphori*, various kinds thereof, 353, 354 & n.
 Their nature, 355, 481
 Whether they retain and imbibe fire, 353 n
 Of urine, and the manner of preparing them, 203, 204 p
 Cause of their burning, 354
 Manner of keeping, 204 p
 Fulminate in the dark, 353, 354 n
 Obtainable from alkaline vegetables, 89 p
 Known to Roger Bacon, 30 n
 To Lully, 33 n
Physica Individuorum, what, 12 n
Physiology, how illustrated by chemistry, 174, 175
Pilule perpetue, what, 122 n
Pisafphaltum, what and whence, 118 & n
Pitch, what, 145 n
 How procured, *ib.* 76, 77 p
Pit-coal, what, 118 & n
 Fewel of fire, 337
Pith in plants, what, 137, 138 n
 Its use, 138 n
Plague, a preservative against it, 133 p, 267 p
 An excellent remedy for it, *ib.* *ib.*
 How affected by alcalies and acids, 162 p
 Whence, 182 p
Planets, whence denominated, 67
Plants, their origin, 135 & n
 Their seed, what, 135 n
 Their flowers, what, 141 n
 Their pistil, what, with its office, *ib.*
 Their generation explained, 141, 142 n
 Their apices, with their uses, &c. what, 141 n
 Their farina, with its office, what, *ib.*
 Their stamina, what, *ib.*
 Their juices classed, 146
 Whether any part thereof be without iron, 140 n
 Whence perpendicular in their growth, 143 n
 Their chyle, blood, &c. 146
 Succulent, how prepared for fermentation, 110 p
 See *Vegetables*.
Pliny, his account of extracting gold from
 orpiment, 17
 Of making glass malleable, *ib.*
Poetice, what, 11 & n
Pokurine, for glass, how made, 183 n
Pot-ashes, *Russia*, what, and how made, 532
Powers of nature, how far observed hitherto, 155 n, 173 n
Precipitate, white, how made, 306 p
 Its virtues and uses, 306, 307 p
 Red, how made, 307, 308 p
 Its properties, 308, 309 p
Precipitation, what, and how procured, 338, 339 p
 Its chemical doctrine, *ib.*
 May be effected without a mixture of alca-
 lies and acids, 339 p
 How effected, and by water, 467
Prince's Metal, what, 93 n
 Why so called, 153 n
Principles in Chemistry, what, 80 n
 By whom first advanced, 35 & n
 Whether pre-existing in bodies, 158
 Their several Offices in composition, 158 n
 Active and passive, 159 n
 Intermediate, which, *ib.*
 Not strictly elementary, 158, 159 n
 Difficult to ascertain, 543
 See *Elements*.
Processes, what, 1 n, 3 p
 How deliver'd to best advantage, 4 & n, 2 p
Prognostics of diseases, to be formed from che-
 mistry, 175, 176
Proofs from ancient manuscripts fallacious, 7 n
Pseudo-diamond, its difference from the true
 diamond, 120 n, 123
Pubvis fulminans, its effect accounted for, 190 n
Putrefaction, its nature and uses, 182 p
 Produces the most intense heat, 298
 With what degree of fire produced, 374
 Not performed without water, 467
 Greatly favour'd by the air of some places, 407, 408 & n, 468
 Whence caused, 182 p
 Its difference from fermentation, 105, 106 p
 182, 183 p
 Its phenomena in vegetables, 181, 182 p
 How it converts vegetable into animal sub-
 stances, 182 p
 The medium of converting vegetable into
 animal substance, & vice versa, 182 p
 Explains animal digestion, 182 p
Putty, what, 100 n
Pyrotechnia, an appellation of chemistry, 12 n

Q

- Quick-Lime*, fire imprison'd therein, 220 n
Quicksilver, its chemical character ex-
 plain'd, 68, 69 n
 Its nature, metalline, 68, 69 n
 Nearly allied to gold, 69 n, 82
 Its specific gravity, 70, 80 & n
 May perhaps be made heavier than gold, 80 n
 Its fluidity, 81 n
 Least malleable of all metals, 81 & n
 Its great separability, 81 n
 Smoothness of its parts, *ib.*
 Its particles used as a *camera obscura*, *ib.*
 Its divisibility, *ib.*
 Volatility, 81 & n
 Recoverable from its fumes, 81 n
 How to fix it *per se*, *ib.*
 Ill effects of its fumes, *ib.*

I N D E X.

- Quicksilver*, with what metals disposed to unite, 81 & n. 82 n
 Whether it will amalgamate with iron, 82 n
 Best handled with iron instruments, *ib.*
 Its use in gilding, 82 n
 In separating silver, 89 n
 Cleaves only to metals, 81 & n. 82 n
 Its disposition to receive heat and cold, as
 its gravity, 82 n
 Contains fire, 238 n
 Not congealable by cold, 82 n
 Dissolvable in acids, except vinegar, 82 & n
 Convertible into different medicines, 83 n
 Its manner of acting in the body, 82 n
 Its medicinal virtues, whence, *ib.*
 To know if it be adulterated, *ib.*
 Its simplicity, and whence esteemed a che-
 mical principle, 80 & n
 Of the philosophers, its purity, 80 n
 A compound body, *ib.*
 Convertible into metal, *ib.*
 Its rarification in boiling water, 235, 236
 The coldest of all fluids, 238 n
 Contains fire, *ib.*
 Convertible into gold, 101 n
 Void of acrimony, 82 n
 Where found, and in what forms, 82 & n.
 How separated from the ore, 83 & n
 How clear'd of arsenical matter, 83 n
 How clear'd of earth, *ib.*
 How it goes to the composition of metals, 101 n
 What hinders its being gold, *ib.*
 How dissolved and crystallized with *aqua*
fortis, 305, 306 p
 How made soluble in water, 305 p
 How it raises a salivation, 307 p
 Virtues and uses of its solution in *aqua*
fortis, 305 p
 Its solution giving a purple stain, *ib.*
 Properties and uses of its vitriol, 305, 306 p
 How precipitated out of *aqua fortis*, 306 p
 Its red precipitate, or calx, how procured,
 307, 308 p
 How recoverable from its solution, 308 p
 Made more active by acids, 309 p
 How dissolved with oil of vitriol, 310, 311 p
 Its solution in oil of vitriol poisonous, 311 p
 Its fiery oil how made, 312 p
 Whence called *Ignis gehennæ*, *ib.*
 Its poisonous nature, *ib.*
 Its fixation, how approximated, 313 p
 How made into æthiops, *ib.*
 How recover'd from æthiops, *ib.*
 Its virtues, when greatest, *ib.*
 How recover'd from cinnabar, 314 p
 How amalgamated with lead, &c. 315, 316
 See *Mercury*.
Quintessence, what, 155 p
Quintessences, liquid, how prepared, *ib.*
 Their virtues and uses, 155, 156 p
 Dry, how prepared, 156 p
 Their virtues and uses, 157 p
 R.
RAIN, how formed, 402, 403.
 Water, how obtainable in its purity, 460
 Its lixivious nature, 458
Rarification, the sign of fire, 213
 Peculiar to fire, 338
Realgar, what, 115
Reasoning justly, the importance thereof, 4 n
Receiver, chemical, what, 585
Recomposition, whether to be effected in che-
 mistry, 167
Regulus of Antimony, how made, 323 p
Martialis Stellatus, how made, 325 p
 Properties and uses of its scoria, *ib.*
 Its virtue not inexhaustible, 323 p
Relative weight of bodies uncertain, 219
Refina terre, what, 114
Retort, what, 583
Rhazes, the first who extracted virtues from
 drugs, 26
Rickets, how remedied, 321 p
Ripley (George) his character, writings and
 opinions, 31 & n
Rivers, whence, 403, 463
Robs, what and how made, 17 p
 Their nature and uses, 83, 84 p
Rochetta, what, 183 n. 530
Rock-crystal, what, 122 n. 457
Rock-nitre, what, 109 n
Roots of Plants, what, 134 & n
 Their use, *ib.*
 How fitted for fermentation, 110 p
Rosemary, its native spirit, or fragrant water,
 how procurable, 9 p
 Its nature and use, 9, 10 p
Roses, by their odour causing great disorders,
 11 p
 Their oil, how gained to advantage, 69, 70 p
 Virtues thereof, 81 p
Resin, what, 144, 145, 74 p. 78 p. 150 p
 Whence, 78 p
 How made, 96 p
 Its virtues and uses, 95 p. 151 p
 Wherein different from colophony, 95 p
 How gained from resinous tinctures, 150 p
 Prepared three ways, *ib.*
 Generally purgative, 151 p
 How best exhibited, *ib.*
 Its force, how abated in the body, *ib.*
 Of the earth, what, 114
Ruby, what, 123 n
Rue, virtues of its Oil, 81 p
 Of its water, 49 p
Rupescissa

I N D E X.

Rapescissa (*Job. de*) his character and writings, 34 & n
Rust of a metal, what, 286
 How prevented in metalline utensils, 94 n

S.

S*accharum Saturni*, how made, 288 p
 Its virtues and uses, 288, 289 p
 No safe internal, 289 p
 A slow poison, *ib.*
Saffron, diffusive virtues of its extract, 153 p
Sal-Ammoniac, ancient, its origin, 110 & n.
 206 p
 Whence its name, 110 & n
 Whether native or factitious, 205 p
 Its character, 206, 207 p
 The ancient, whether the same with ours, 110 n
 Modern, whether native or factitious, 111 n
 Whereof it consists, 210, 211 p. 111 n
 Whence it comes, 111 n. 205 p
 How made, 111 n. 205, 206 p
 Whether made with, or without sublimation, 111 n. 205, 206 p
 Its dissolving power, 555, 556
 Its power of volatilizing metals, and minerals, 208 p. 284 p
 Its kinds, 206 p
 How purified, 111 n. 207, 208 p
 Its virtues, and uses, 111 n. 206 p
 Gives coldness to water, 110 n. 206 p
 Is neither acid nor alkali, 206 p
 How purified by sublimation, 207, 208 p
 Its nature betwixt volatile and fixed, 206, 207 p
 How distinguished from animal salts, 208 p
 Unchangeable by sublimation, 555. 208 p
 Whence called *aquila alba*, &c. 555. 207 p. 284 p
 Distilled with quick-lime, 208, 209 p
 Virtues and uses of its volatile spirit, 209 p
 With fixed alkali, 209, 210 p
 Affords an exceedingly strong volatile and alkaline salt, *ib.*
 Reduced to a sea-salt, 211 p
 Its regeneration, 261, 262 p
 Its extemporaneous production with spirit of salt, 261, 262 p
 Whereof it consists, 262 p
Sal circulatum Paracelsi, what, 528
Sal-gem, what, 105 & n.
 The finest, where found, 105 n
 Mountains of it, *ib.*
 Unknown to the ancients, *ib.*
 How dug in the mines in *Poland*, *ib.*
 Ground to flower by the mill, *ib.*
 Of two kinds, *ib.*
 Scarce differs from sea-salt, 106. 107 n
 See *Sea-salt*.
Sal mirabile, *Glauber's*, of nitre, how made, 252, 253 p

Glauber's, of sea-salt, how made, 260 p
 Its virtues, properties, and uses, 260, 261 p
Sal-polybreftus, what, and how made, 244, 246 p
 Its nature, virtues and uses, 246 p
 Its name, whence, *ib.*
Sal prunella, how made, 245 p
 Whence the name, *ib.*
 Its virtues, *ib.*
Sal volatile oleosum, the simple how made, 233 p
 Its original author, 36 n
 How varied, 234 p
 The compound, how prepared, *ib.*
 The specific, how prepared, 235 p
 How to be varied, *ib.*
 Extemporaneous, how produced, *ib.*
 Its virtues and uses, 236 p
 In what cases properly used, *ib.*
Salt, sea-salt, what, 105, 106 n
 Where found, 105
 Where, and how made, 106 n
 Is of two kinds, *ib.*
 Its use to the ocean, *ib.*
 Its rise, whence, 107 n
 The same with sal-gem, 106. 107 n
 Its depuration, and crystallization, 256 p
 Not alterable in the body, 107 n. 195 p. 204 p
 Its dissolving power, 556, 557
 Its natural uses, 107 n. 205 p. 257 p
 Medicinal virtues, 202 p
 Whether a solvent for the stone, 205 p
 How regenerated from sal-ammoniac, 261 p
 The only solvent of gold, except mercury, 73 & n. 107 n. 257 p
Glauber's spirit thereof, how made, 257, 258 p
 Its virtues, and uses, 258 p
 Convertible to acid, *ib.*
 To *sal-mirabile*, 260 p
 Its spirit with bole, 259, 260 p
 Animal, its nature and character, 152
 The principle, what, 158 n. &c.
 A vague one in the earth, 113 n
Bay-Salt, whence its name, 106 n
 How, and when made, *ib.*
Rock-Salt, what, 105 & n
White-Salt, what, 106 n
 Where, and how made, 106, 107 n
 How made from bay salt, 107 n
 How extracted from the salt-springs of *England*, 105, 106 n
 How purified, 256 p
 How decrepitated, 259 p
 Its fixed and unchangeable nature, 195 p. 204 p
Salt Marsh, what, 106 n
 How made, *ib.*
Salt-Mines, supplied with fresh water, 105 n
Salt-Petre, see *Nitre*.
Salt-Springs, how treated for salt, 105, 106 n.
Salt.

I N D E X.

- Salt of tartar*, how made, and procured to advantage, 142 p
 How made volatile, 167 p
 Made to give a red tincture with pure alcohol, 170 p
 Made into a waxy substance, 168 p
 How procured, 141 p. 170 p
Harvey's tincture thereof, 169 p
 Its virtues and uses, 169, 170 p
Helmont's tincture thereof, how made, 170, 171 p
 Its nature, 171, 172 p
 Requisites to the extracting its tincture, 170, 171 p
 Whether it will yield any tincture to alcohol, 170, 171 p
 Uses, and virtues of it, 171 p
Salts, defined, 104 & n. 529
 Division thereof, 105, 163 n. 529
 Fossil, of two kinds, 105 n
 Perfect, which, 107 n
 Native, which, 105 & n. 107, 108, 109 n
 Factitious, which, 105 & n. 106 n. 108 n. 109 n
 Only act, when dissolved, 221 n
 Their solvent, 448, 449
 Their composition, 163 n. 164 n
 Their figures, crystals, &c. 106
 How converted into one another, 261, 262 p
 Their solution in water, how accounted for, 444
 Vegetable, infinite species thereof, 41 p
 The acid, classed, 163 n
 The intermediate, what, *ib.*
 Their manner of action, whence, *ib.*
 The urinous of three kinds, 163, 164 n
 Producing, and convertible into each other, 164 n
 Are menstruums, 529
 Compound, what, and which, 559, &c.
 Their knowledge of the utmost importance, 528
 Essential, or native, how procurable, 23, 24 p
 Their species, 24 p
 Not simple bodies, 25 p. 26 p
 Into what resolvable, 25 p
 Have the virtues of their plants, but in a greater degree, 24 p
 How obtainable from plants, 31, 32 p
Salis nitrous, of plants, which, 24 p
 Impediments to their shooting, *ib.*
 Shoot in fermented juices, 25 p
 Medicated, how prepared, 26, 27, 28 p
 Virtues thereof, 28, 29 p
 May be used as sea-salt, 28 p
 How, and with what caution to be administered, 30 p
Saponaceous, how obtained, 27, 28 p
 How separated, purified, whitened, &c. 168 p. 241, 242 p
 How regenerated, 166, 167 p
Alkaline and fiery with lime, how made, 39 p
 Fixed, what, and whence, 478, 409
 Owe their chiefest part to elementary earth, 478
 Not simple, but compounded, *ib.*
 Not naturally contained in vegetables, 20 p. 41 p
 Very different from the native, 41 p
 How procured from vegetables, 33, 34 p
 How in greatest quantity, 27 p. 32 p. 40 p
 How made for glass, 183 n
 Their matter originally volatile, 40 p
 Are the production of fire, *ib.*
 Do not naturally pre-exist in the subject, 40, 41 p
 Their difference, whence, 41, 42 p
 Corrosive, whence, 42 p
 Violently corrosive, how made mild, 41 p
 Detain fire, 42 p
 Their composition, *ib.*
 Are capable of crystallization, 42, 43 p
Animal, what, and whence different from the vegetable, 89, 90 p
 Neither acid, nor naturally alkaline, 189, 190 p
 Their effects in the body, 190, 191 p
 Their nature changeable, except that of sea-salt, 195 p
 Whether they all proceed from acid and earth, 42 p
 Not naturally volatile in the body, 224 p
Essential, of the human body, what and how procured, 194, 195 p
 Their volatility, 224, 225
 Universally the same, 226 p
 When turned alkaline, prove mortal, 217
Salts mineral, how impregnated with their own acids, 249, 250 p. 261 p
 Recoverable from their acid spirits, 249, 250 p
 How united with the vegetable salts, 278, 279 p
Neutral, what and whence, 555, 251 p
 Obtainable upon a mixture of acids and alkalies, 251 p
Unalkaline, from a fixed alkali, 42, 43 p
Volatile, what, 216 p
 How purified, 229, 230 p
 All of the same nature, 230 p
 But one in all nature, *ib.*
 Their difference, whence, *ib.*
 Their effects in the body, 231 p
 Are very exhalable, *ib.*
 Of less force than the fixed, *ib.*
 Their caustic virtue, *ib.*
 Their affinity with the fixed, 546
Saltern, what, 105 n
Samech of Paracelsus, what, and how made, 129 p. 164, 165 p
Sand,

I N D E X.

- Sand*, what, 488
 How prepared for glass, 184 n
 For green and crystal glass, whence obtained, *ib.*
 Showers thereof, 474
Sandiver, what, 184 n
Sands, what, 127 n
 Of two kinds, 127, 128 n
 The proper, very durable and not calcinable, 127 n
 Their figure, constant, *ib.*
 Of England, classed, 127, 128 n
 Their office in nature, 128 n
Sapa, what, 17 p
 How, and from what prepared, *ib.*
Saphir, what, 123 & n
 Its kinds, 123 n
 Whence brought, *ib.*
Saps, their nature and composition, 137, 139
 How procurable to advantage, 139 n
Sassafras, its oil how obtained, 73, 74 p
 Its oil heavier than water, 74 p. 79 p
Savin, its virtues, 49 p
 Its essential oil, how prepared, 65 p
 Virtues of its oil, 81 p
Scammony, its tincture, how best extracted, 147 p
Scurvy, a medicine for it, 143 p
Sea, its saltiness, whence, 446 n
Sea-gelly, described, 149 n
Sea-nettle, described, *ib.*
 Its progressive motion, *ib.*
Sea-plants, how produced, 135 n
 See Vegetables.
Sealed earths, their number, 129 n
Seasins, what, and how brought about, 223
 Their difference, whence, *ib.*
Seed, the notion thereof explained, 126, 127 n
 Whether stones arise therefrom, *ib.*
 Its structure in vegetables, 142
 Use of its essential oil, 71 p
Seeds mealy, what, 107 p
 How malted, or prepared for fermentation, 109, 110 p
Semi-metals, defined, 128, 129
 Classed, 129
 Those consisting of metal and sulphur, 131
 Metal and salt, 129
 Metal and earth, 133
 Are menstrua, 490
 Are of three kinds, 129—133
Serum of the blood, what, 217 p
 Is neither acid nor alkali, 217, 218 p. 219 p
 Its nature, how known, *ib.*
 How affected by acids, and alkalies, *ib.*
 Putrefied by digestion, 219 p
 Coagulated with heat, 220 p
 Its affinity to the white of eggs, 219 p.
 220 p. 221 p. 223 p
 Coagulable with alcohol, 221 p
 How preservable uncorrupted, 220 p. 221 p
 How affected by fixed alkali, 228 p
 Volatile alkalies, and sal-ammoniac, *ib.*
 Spirit of vitriol, sea-salt, and mine, 237 p
Sal volatile oleosum, 238 p
Shell-fish, their progressive motion, 149 n
 Nourish their shells, 149, 150 n
Shells of Snails, their formation and increase, *ib.*
 Their structure, *ib.*
 How generated, *ib.*
 Of mussels, how formed, 150 n
 Of lobsters, &c. whence, 151 n
Sideroxylis, its use to the Indians, 241
Signs in medicine, a doctrine improved by chemistry, 175, 176
Silver, its chemical character explained, 68,
 69 n
 Convertible into gold, and how, 101 n
 Its specific gravity, 70. 87 n
 Gained from lead, 86 n
 From tin, 98 & n. 99 n
 Its fixedness, 74 n. 87 & n
 Rendered volatile, 87 n
 By antimony, 88 & n
 Exposed to a burning-glass, 90 n
 Vitrified, *ib.*
 Long kept in fusion, 87
 Strictly unites with tin, *ib.*
 Its ductility, and malleability, 87 & n
 Its fusibility, *ib.*
 How dissolved, 87 & n. 293 p
 Its menstrua, 87 & n
 Soluble in a particular *aqua regia*, 88 n
 Uses of its solution, 294 p
 How separated from gold, 87, 88
 Apt to be lost in separation, 88 n
 Resists lead in fusion, 71 n. 88 n
 Has most of the properties of gold, 101 n
 Wherein it remarkably differs from gold, 88 n. 101 n
 Its found, 90 n
 In what forms found, 88 & n. 90 n
 In gold ore, 88 n
 Contained in gold, *ib.*
 In lead ore, *ib.*
 In copper ore, *ib.*
 Its mines dangerous to work, 88, 89 n
 Its sulphur antimonial, 88 n
 Difficult to procure, on account of the adhering sulphur, *ib.*
 To find how much is contained in any matter, 89 n
 How obtained in *Chili* and *Pern.*, *ib.*
 Pure, how fitted for use, 188
 Its vitriol, or crystal, how obtained pure, 294 p
 Nature and use thereof, *ib.*
 To discover gold therein, 293 p
 Its purging vitriol, how made, 290 p
 How made *Luna cornua*, 299, 300 p
 Silvers.

I N D E X

- Silver*, acquires a new nature, in *Luna cornua*, 300 p
 Reduced to metal again, from its inflammable vitriol, 297 p
Simplicity, its notion explained, 70, 71 n. 362
Skin, certain disorders thereof, how remedied, 98, 99 p
Slare, his character, and chemical writings, 56 n
Smalt, what, and how made, 116 n
Smoke, what, 308, 309. 327 n. 330
 Of Jewels, different, 367, 368
 Some poisonous, 307
 Why offensive to the eyes, 86 p. 87 p
Snails, described, 150 n
 Whence furnished with shells, *ib.*
 Perspire, *ib.*
 How their shells grow, *ib.*
Snow, whence, 404
Snow-water, good in inflammations of the eyes, 460
 The lightest of all rain-waters, *ib.*
Soap, its analysis, 160, 161 p. 162, 163 p
 Of what made, 530
 Of sulphur, how made, 273 p
 Its nature, and uses, *ib.*
 The different kinds, how made, 160, 161 p. 162, 163 p
 How prepared with oils and fixed alkali, *ib.*
 When made most perfect, *ib.*
Soap, its medicinal virtues, and uses, 162 p
 How best exhibited, *ib.*
 An almost universal medicine, *ib.*
 Of philosophers, what and how made, 273 p
 Of *Starky*, what, 164 p
 Why called *Matthew's* corrector, *ib.*
 Its virtues and uses, *ib.*
 How united with alcohol, *ib.*
 The finest, which, 232 p
Soap-boilers *lee*, of what made, 530
Soda, what, *ib.*
Soils, their difference as to heat and cold, 263
Solidity, not requisite in fewel, 328
 See *Fire* and *Light*.
Solids, may have an intestine motion, 215
 Not very different from fluids, *ib.*
Solution, chemical, how and in what manner performed, 337, 338 p
Soot, what, 310
 Its analysis, 310. 475. 177 p. 178 p
 Whence combustible, 310
Sory, what, 136
Sound of copper, increased by tin, 98 n
Spagyrical art, what, and whence so called, 11
Spar, what, 99 n
Sparu-water, how imitated, 277, 278 p
Spelter, what, 133 n
Spheroidal figure of the earth, owing to what, 222
Spirit, what, 162 p
 Its different species, *ib.*
 Native of vegetables, what and where seated, 10, 11 p
 Its great efficacy, 11 p
 Of nitre, how made proof, 293 p
 Of vitriol, preserves water, 459
 Of wine, if a sulphur, 329. 4
 Whether, and how convertible into water, 319
 Its compound nature, 329
 Obtainable the same from all vegetables, *ib.*
 Miscible with water, 452
 Only burns on its surface, 316, 317
Spirits, acid, how producible, 162 n
Alkaline, what, and how obtained, 227 p. 162 n
 How purified, 228 p
 How separated into their principles, 228, 229 p
Vinous, how produced, 162 n
 Gained from animals, what, 228 p
 In animals, what, 151
Spirits, simple, medicated, aromatic, what and how prepared, 157—159 p
 Their virtues and uses, *ib.*
 Compound, medicated, aromatic, how prepared, 159, 160 p
 Producible, 227, 228 p
 How procured, 118, 119 p. 121, 122 p
 Their nature, virtues, and uses, 119 p
 How rectified, or made proof, 122, 123 p
 Rectified, whether acid or alkaline, 123 p
 How made undistinguishable from alcohol of wine, 123 p
 How made into alcohol, 124 p
 When proper menstruums, 147, 148 p
Spiritus nitri dulcis, how made, 248, 249 p
 Its nature, virtues, and uses, 249 p
 See *Nitre*.
Spiritus rector, what, 143. 526
 Contained in oils, 526
Spiritus sulphuris per campanam, what, 337
 The heaviest of saline fluids, *ib.*
Springs, whence, 403. 462
Spring-salt, what, 105 & n
 How made, *ib.*
Spring-water, whence, 462
Stahl, his character, and chemical writings, 59, 60 n
Starkey's pills, what, 164 p
Stars, what, according to *Newton*, 257 n
Steel, what, and how made, 96, 97 n
Stones, defined, 120
 Wherein they differ from metals, and other minerals, 120 & n
 Classified, 120, 121
Precious, which, 120 n. 122, &c.
Transparent, what, 122 & n
Semi-transparent, what, 124
Opaque, what, 124, 125
 Their origin, and formation, 125 n
Stones,

I N D E X.

- Stones*, were once fluid, 125, 126 n
 Opaque, how formed by nature, 125 n
 Counterfeited, 120, 121 n
Vulgar, their nature, 124
 How convertible into glass, 125
 Classed, 120 n
 Their origin and formation, 125 n
Stones vulgar, whether they grow in the quarry, 125 n
 Whether organized, *ib.*
 Whether they rise from seed, *ib.*
 Were once fluid, 126 n
 Growing like plants, 125 n
 All their basis, earth, 126 n
 Their criterion, 120 n
 Engraven, how finely copied on glass, 187, 188 n
 Human, its menstruum, 203 p. 205, 249 p
 How prevented, 205 p
 Whether its menstruum be contained in urine, *ib.*
 Whether caused by iron, 95 n
 Medicines for it, 107 p. 165 p. 249 p
Sublimate corrosive, how made, 309 p
 Its nature, and uses, 309, 310 p
Succory, virtues of its native salt, 24 p
Sudorific, an innocent, and powerful one, 133 p
Sudorifics, what, and how they act, 29 p
Sugar, what, 100 p
 Whether prejudicial to the body, 100, 101 p
 Its medicinal virtues, 101 p
 Its nature hard to settle, *ib.*
Sulphur, fossil, defined, 113, 264—268 p
 Species thereof, 113, 114 & n
 Fewel of fire, 327-337
 Native, what, 114 n
 Factitious, how obtained, *ib.*
 Of what made, 304
 Its uses and virtues, 114 n
 Its vapour causes suffocation, 337
 Whether fire itself, 313
 Its fume, a preservative, 267
 Acid thereof, 337. 266, 267 p
 Recomposed, 114, 274 p
 Its flame, what, 113
 Yellow, what, 214 & n
 Supposed antidotal, 267 p
 Common, whence obtained, 114 & n
Vitrum, what, and where found, *ib.*
 Makes metals brittle, 268 p. 73 n
 Whence known to abound in ores, 268
 Volatilizes metals, 74 n
 Not touched by acids, 267 p
 Hinders quicksilver from being gold, 101 n
 Its properties and characteristics, 264 p
 Neither acid nor alkali, *ib.*
 Allied to rosin, *ib.*
 Whether it may be made metalline, 265 p
 How sublimed, purified, or turned to flowers, 264, 265 p
 Which best, the native or purified, 265 p
 Whereof it consists, *ib.*
 Its uses in fermentation, 114 n. 117 p. 267 p
 Its fume, how it becomes poisonous, 337
 264 p. 267 p
 How dissolved in fixed alkali, 268 p
 Its oil *per deliquium*, how made, *ib.*
 How render'd soluble in water, *ib.*
 Its tincture resembling that of gold, 269 p
 How discoverable in ores, 268 p
 How dissolved in volatile alkalies, 269 p
 Its virtues and uses, when dissolved by alkalies, 268, 269 p
 Its tincture with alcohol how made, 269 p
 How made into a Syrup, 270 p
 How turned into balsams, 271 p
 How dissolved in expressed oils, *ib.*
 Distilled oils, 272 p
 With what oils it dissolves the best, 271, 272 p
 How dissolved in alcohol, 267 p. 269 p
 Virtues of its solution in alcohol, 270 p
 Its soap, how made, 273 p
 No extraordinary internal remedy, *ib.*
 How generated from oil of turpentine and oil of vitriol, 274 p
 How generated from oil of vitriol and alcohol, 275, 376 p
 Its magistery, how made, 269, 270 p
 How precipitated in solutions, 271, 272 p
 May lie latent in fossils, 270 p
 Of metals, what, 101 n. 134 n
 The principle, what, its nature, genesis, &c. 158 n. 164, 165 n
 Procurable from various matters, 165 n
 Whence, in metals, *ib.*
 Obtained from cinnabar, *ib.*
 Conceiving heat, &c. with iron filings 356
 By what absorbed from metals, 268 p
Fixing, what, 134 n
Sun, its nature, 240 n
 According to *Lemery*, *ib.*
 What according to *Newton*, *ib.*
 Its manner of acting on terrestrial bodies, *ib.*
 Heat how occasioned thereby, 269
 Why not exhausted, 257 n
 Its heat rarely destroys animals or vegetables, 261
 Its force different in different places, 261, 262
 Not requisite to produce the intensest fire, 281
 May emit no fire, 281, 282
 Effects of its heat upon the vegetable kingdom, 9, 10 p
Sutratar, what, 357
Sylvius's febrifuge salt, what, 311 p
Syrup, what, 117

I N D E X.

T.

T*achenius*, his method of making medicated salt, 26, 27 p
Tansey-Water, its virtue, 102 p
Tarso, what, 184 n
Tartar, what, 533. 25 p
 Its origin and production, 533. 139 p
 By what wines afforded in greatest plenty, 533. 25 p
 How formed in the vessel, 25 p
 Which the best, 25 p. 139 p
 Is of the same colour with the wine, 533. 25 p. 139 p
 Into what resolvable, 533
 The effect of fermentation, 533. 534. 115 p
 Not volatile in water, 139 p
 To encrease its quantity in the cask, 25 p
 How made to serve as a vessel, 165 p
 Difficult of solution in wine and water, 25 p. 199 p. 165 p
 How resolved, 140, 141 p
 Its water, spirit, oil and fixed alcali, *ib.*
 Its penetrating nature in distillation, 140, 141 p
 Uses of its distilled oil, 141, 142 p
 Soluble or tartarized, how prepared, 164, 165 p
 Its virtues and uses, 165 p
 An excellent menstruum, *ib.*
 Its tincture, how made, 168 p
 How made readily dissolvable in water, 165 p
 Regenerated, or *terra foliata tartari*, how prepared, 166, 167 p
 How made into a tincture, 168 p
 Its virtues and uses, 168, 169 p
 A cheap substitute for it, 169 p
 How calcined, 170, 171 p
Tartarum Vitriolatum, how made, 262, 263 p
 Its virtues and uses, 263 p
Tastes, the chemical doctrine thereof, 341 p
Teats of Trees, how best procurable, 139 n
Tendons shrunk, how remedied, 95, 96 p. 142 p
Terra foliata tartari, how prepared, 166, 167 p
 Whence the name, 167 p
 Whence it yields a copious oil, *ib.*
Tests, the best earth for making them, 308, 475. 482. 19 p
Thaw, effects thereof, 272
Therapeutics, derived from chemistry, 177
Thermometers, the best made of mercury, 299
Thiarcum Nicandri, what, 118
Thunder, whence, 271. 404
Tin, its chemical character explained, 68, 69 n
 Its nature, *ib.*
 Nearly allied to silver, 98 n
 Its specific gravity, 70
 Why prevented by water from melting, 289
 Its softness and ductility, 98 & n

Its great volatility, 98 & n
 Its effluvia poisonous, 98 n
 Its calx reducible, 99 n
 Some parcels approach to silver more than others, *ib.*
 Its difference from lead, *ib.*
 Of difficult solution in acids, unless calcined, 98 & n
 Its medicinal virtues, 100 n
 How to be calcined, 98 n
 A specific for the epilepsy and hysteric fits, 100 n
 Its elasticity and sound, 98 & n
 Where found, 99 & n. 100
 Gave the name to *Britain*, 99 n. 100
 Its ore, how wrought, 99, 100 n
 How separated, *ib.*
 How calcined, dissolved and crystallized, 300, 301 p
Tincal, or *Tinear*, what, 109 n
Tinctures, how made from resinous vegetables, 142—148 p
 Which made with alcohol, and which with alcohol and fixed alcali, 142, &c. p. 144, 145 p
 Their red colour, whence, 145 p
 Of vegetables, what they contain, 143 p
 Their virtues, *ib.*
 Resinous, how precipitated into rosin, 150 p
 From metals, what, 268, 269 p
 Sulphurous, their virtues and uses, *ib.*
Tin-Glass, what, 132 n
Tinning, what, 100 n
Topak, what, 124 n
Torrifying of Ore, explained 76 n
Transmutation of metals, whether at all real, 103
 Shewn to be possible, 102 n
 Directions how to proceed therein, *ib.*
Trees, their manner of growth inquired into, 136, 137, 138 n
 Their bleeding, 139 & n
 How best tapped for their liquor, 139 n
 Effects of their effluvia, 11 p
 How defended in cold seasons and climates, 58 p
 When said to grow old, *ib.*
 When best fitted for timber, 59 p
Tripoli, its uses, 187 n
Tristuration, its force in effecting solutions, 502
 Its great effects in chemistry, 502 & n
Tubal-Cain, the same with *Vulcan*, 12 & n
Turf, its kinds, 367
 The *Dutch*, its peculiarities, 9 n
Turpentine, its analysis, 93, 94 p
 Pills, what, 146 n
Turpetum minerale, how made, 310, 311 p
 Its nature, virtues and uses, 311, 312 p
Tutting, what, 133 n

V.

I N D E X.

V.

Valentinus (*Basil*) his history, writings, opinions and discoveries, 35 & 4
 First applied chemistry to medicine, 35 n
Valerianians, an excellent remedy for them, 30 p
Vapours, as different as the climate and soil, 415, 416 & 417 n
Vegetables, what, 66 n, 134
 Their distinguishing character, 168
 How fed by the earth, 128 n
 Their nourishment, what, 136 n
 Distinguished from fossils and animals, 134
 How nearly analogous to animals, 134 n, 151
 Their wounds to be treated as those of animals, 134, 135 n
 Whether they always grow from the earth, 135 n
 Whence they grow upwards, 143, 144 n
 Their vascular structure proved, 135 n, 4 p
 Matter of their vessels, 135
 Their absorbing vessels, 135 & n, 4 p
 Office of their roots, 134 n, 136, 4 p
 Their sap, of what composed, 137, 140
 How raised, 135, 136, 4 p
 Progress and preparation thereof, 140
 Have a kind of respiration, *ib.* 4 p
 Have their atmosphere, 11 p
 Consist of circulating vessels and air-vessels, 140, 4 p
 Circulation, if at all, whence effected in them, 135, 136 n, 4 p
 Whether they are fed by the bark, wood, or pith, 136 n
 To retard their blossoming and bearing, 137 n
 Their manner of growth enquired into, 136, 137, 138 n, 4 p
 Their manner of generation explained, 141, 142 n
 Their leaves, 140
 Office and importance thereof, *ib.*
 Juices thereof, *ib.*
 Various kinds thereof, 5 p
 Their chyle, how elaborated, 140
 Their fruit, 142
 Their seed, 142, 143 n
 Their manner of growth, 143 n
 Their bark, what, 138 n
 Uses thereof, 137 n
 Their digestion, how performed, 140
 Their blood, or peculiar juices, 146, 5 p
 How distinguishable by chemical analysis, 146 & n
 Their popular division, 147 n
 How classed by botanists, *ib.*
 Have excretory ducts, 5 p

Different juices in the different parts thereof, 6 p
 Have different juices at different times, 7 p
 In what their difference consists, 23 p
 Differ in their odours and tastes, 6 p
 At first abound into watery saline juices, 7 p
 Their peculiar virtues, whence, 146
 Into what parts resolvable, 146 n, 170 n
 Fewel of fire, 301
 Process of ignition in them, 301
 Their water, whether the fewel of fire, 303, 304
 Their native spirits, whether the fewel of fire, 304
 Their volatile and salts, whether the fewel of fire, 305
 Their oil the fewel of fire, 306, 311
 Putrefied, take fire, 311, 312
 Their specific virtues, how exalted, 56 p
 Have valves in their vessels, 4 p
 Their receptacles, 5 p
 Their scent and taste, whence, 11 p
 Their native spirit small in quantity, 10 p
 What and where lodged, 10 p
 The vapour, or water they spontaneously exhale in the summer, 11 p
 Their native spirits or fragrant waters, how procurable to advantage, 9, 10 p
 How affected by the summer's sun, 7 p, 11 p
 A catalogue of those fittest to afford simple waters, 12 p
 The aromatic, which, 12 p
 Whether the tasteless and inodorous may be medicinal, 11 p
 Composition of their aromatic simple waters, 9, 10 p
 Their specific virtues whence, 10 p
 What they lose by exiccation, 11 p
 What they part with in distillation, *ib.*
 Their effluvia, what, *ib.*
 Reducible to oil by coction, 14 p
 The utmost effect of boiling water thereon, 14 p
 The tenderest, whence undestroyed by the sun, rain, &c. 20 p
 How reducible to white insipid ashes, 18, 19 p
 Saline ashes, 21 p
 Of what parts they consist after decoction, 16 p
 How affected by long keeping, 20 p
 Naturally contain no fixed salt, 137 p
 The more volatile, the less they yield of fixed salt, 22 p
 Their salt and oil, how united, 21 p
 Their salts, how naturally existing therein, 23, 24 p

I N D E X.

- Vegetables*, their native or essential salts, how procured, 23, 24 p
 Their several species of salts, 24 p
 When they abound in salt, and when in oil, 59 p
 How made to afford a large quantity of salt, 26 p
 Their decoctions, what, 47 p
 The vapour of their decoctions what, 47 p
 The scent of their oil, 58 p
 When said to sleep, 58, 59 p
 The sun's action upon the aromatic tribe, 78 p
 Method of resolving them, 84, 85, 86 p
 Their acid spirit reducible to water, 85 p
 87 p
 Whence red, 86 p
 In what manner they contain oil and acid, 85 p
 The virtues of their acid spirits, what and whence, 87 p
 Their acid small in quantity, *ib.*
 Their native oils, how cleansed, 85, 86 p
 Their empyreumatic oils, how cleansed, 86 p
Alcaline, how analysed, 88, 89 p
 Approach the nature of animal subjects, 89, 90 p
 Afford alkaline salt without putrefaction, 90 p
 Their oils and salts, how purified, 89 p
 Afford no inflammable spirit without fermentation, 103, 104, 105, 106 p
 Classed with regard to fermentation, 106 p
 108 p
 The requisites to their fermentation, 109, 114 p
 To be treated as malt for brewing, 109, 110 p
 How fitted for brewing, 109, 111 p
 The general method of committing them to fermentation, 111, 112 p
 By putrefaction made animal, 181, 182 p
 Putrefied, how analysed, 181 p
 All subject to putrefaction, 180 p. 182 p
 Reducible by putrefaction to the same common nature, 181 p. 182 p
Vegetation explain'd, 135, 136, 137 n
 Chemical, what, 249, 250, 251 p
Veneral Disease, its rise, 36. 40 n
 How cured by *Carpus*, 36
 How cured by *Paracelsus*, 40 n
 Medicines for it, 147 p. 311 p
Venery, the appetite, how destroyed, 241 p
Verdigrease, what, 93 n. 137 p. 286 p
 Its fine emetic quality, 92 n
 Distilled, what, 138 p
 A pigment, *ib.*
 A strong attractive of the acid of vinegar, 138, 139 p
- Alters not the nature of vinegar, 139 p
 Its virtues and uses, 138 p. 302 p
Vermilion for painting, how prepared, 179 n
Vessels, chemical, what, 580
 Their kinds, 581
 Metalline, their inconveniences, 581, 582
 Of what best made, 581
 Wooden, their use, *ib.*
 Earthen, when to be chose, 582
 Which the best, *ib.*
 Of glass, their excellence and uses, 581
 How chose, 581, 582
 Their imperfection, 581
 Their figure to vary as their uses, 582, 583
 Reasons of the diversity of their figure, *ib.*
 Reducible to two kinds, 582, 583
Vibration, whether the cause of heat, 296
Villette's Speculum, its power, 267
 Compared with *Tschirnhause's*, 278
 Of what made, 267
 Its figure, *ib.*
 Diameter of its focus, *ib.*
 Its conveniences and inconveniences, 268, 269
 Its effects, 267
Vinegar, what, and whence, 106 p. 129 p
 132 p
 Its origin and production, 130 p
 How made in *France*, 130, 131 p
 Its subjects, 130 p
 An artificial thing, 129 p
 Differs from native acids, 135 p
 Best made from generous wines, 130, 131 p
 Is not corrupted wine, 131 p
 Deposits a saponaceous matter in the making, *ib.*
 Its rape, how to be cleansed, *ib.*
 The better for use, *ib.*
 Its containing vessels the better for use, *ib.*
 May be advantageously prepared from malt-liquors, 131, 132 p
 How improved by spice, 134 p
 Its nature, properties, medicinal virtues, and uses, 132, 133 p
 Its virtues, whence, 133 p
 Contains an inflammable spirit, 134 p
 The tartar of the wine, 132 p
 A fluid tartar, *ib.*
 Its power as a menstruum, 547
 How procurable from balsams, 92, 93, 94 p
 Of balsams, and balsamic woods, its virtue, 95 p
 What it affords in distillation, and in what order, 134, 135 p
 Whether it yield an ardent spirit by distillation, 134, 135 p
 Liquifies the animal juices, 133 p
 How analysed or distilled, 134, 135 p
 Virtues and uses of its spirit, 136 p
 Vine-

I N D E X

- Vinegar*, its spirit a great antidote, 133 p
 Uses of its rectified spirit, 137 p
 Distilled, how rectified, *ib.*
 Affected differently from wine by rectification, *ib.*
 How rectified from metals or verdigrease, 137, 138 p
 Rectified from verdigrease, its virtue, 138, 139 p
 Its rob or extract, 134, 135 p
 Affords a strong fixed alcali, 135 p
 Virtues thereof, 136 p
 Affords an inflammable liquor, distilled from lead, *ib.*
 A more elaborate production than wine, 129 p
 Impaired by boiling with animal substances, 137 p
 Its proportion of acid salt, 167 p
 Thins the blood, 237 p
 Natural, of the plant, what, 57 p
 Of the philosophers, what, 547
Vitrification of Gold, 74 n
Vitriol, what, 129, 130 n
 Of two kinds, 130 n
 Native, of two kinds, 129
 Whence obtained, 130 & n. 277 p
 Always found with copper, 91 n
 Where found, 130 n
 Its diversity of colour, whence, 131 n
 Roman, how procured, 130, 131 n
 Green, how made, 131 n
 White, 130 & n
 Its component parts, 131 n. 319 p
 Its calcination, 318 p
 Its analysis and recomposition, 130, 318, 319 p
 Its acid, what, 129
 Artificial, made from all kinds of metals, 129, 130
 Its uses, 131 n
 Vitriols of metals, how gained, 277 p
 Of iron, its virtues and uses, 277, 278 p
 Its spirit, oil, and colcothar, how procured, 318, 319 p
Ukers, foul, how cleansed and cured, 138 p
 271, 272 p
Ultramarine, what, and how made, 133 n
Universal Medicine, when first pretended to, 16, 17 n. 33, 36
 Unknown to the ancients, 16 n
 The notion probably derived from *Galen*, 26
 Whether known to *Paracelsus*, 16 n. 41 n.
 45
Van Helmont, 45 & n
 Probably not to any, 45 n
Volatility, the notion thereof in chemistry, 74 n
 See *Fixedness*.
Volatilization, effected by air, 407
Vomit, sudden one, 302 p
Vomiting, remedies against it, 49 p
Urinal, what, 584
Urine, its nature and contents, 189, 190 p
 Morbid, differs from the healthy, 191 p
 Affords nothing acid nor alkaline by distillation, 191 p
 Its analysis, 191, 192 p
 Contains no inflammable spirit, 192 p
 The sharpest salts of the body, 191 p
 How to be regarded and judged of as a sign, 193, 194 p. 201 p
 Its rob distilled with sand, 194, 195 p
 Contains sea-salt, 191 p. 195 p
 Turned alkaline by being distilled with fixed alcali, 195, 196 p
 Distilled with quick-lime, what it yields, 197 p
 Its fiery spirit, when distilled from quick-lime, *ib.*
 Its medicinal uses, 197, 198 p
 Crystallized, 198, 199 p
 Its essential salt, how obtained, *ib.*
 Nature thereof, *ib.*
 How digested, 201 p
 Turned alkaline by digestion, *ib.*
 Its suppression, where mortal, *ib.*
 Digested, its analysis, 203, 204 p
 Its use in scouring and dying, 201 p
 Shewn to be naturally neither acid nor alkaline, 190, 191 p
 In what time perfected in the body, 190 p
 Apt to putrefy, or turn alkaline in the body, 191 p
Uterine Medicines, 67 p. 76 p. 80 p. 145 p
Vulcan, or *Tubal Cain*, the inventor of chemistry, 12 & n. 13, 14 n
 W.
WARTS, how taken away, 38 p
Water defined, 437, 465
 Enters the composition of all bodies, 87 p
 Present in air, 399, 403, 436
 Forms the greatest part of common air, 400
 Whether a principle, 154 n
 Turned to ice at great heights, 404
 Causes of its ascent, 405
 Why hard to be known, 436
 Whether convertible into air, 436 n
 Contained largely in bodies, 436 & n. 446 n.
 466, 87 p
 Impossible to obtain it pure, 437
 Its peculiar weight difficult to find, 439
 Well-water, what and whence, *ib.*
 Which the wholesomest, 440 n
 Which the purest, 520
 How to discover its purity, 440 n. 465
 Sea-water, how made sweet, 440 n
 Its fluidity, what, 441
 Depends on fire, 220 n. 441
Water.

I N D E X.

- Water*, its fluidity invariable, 442
 Smallness of its particles, *ib.*
 Its penetrability, 442 & n
 Its particles made finer by cold, 444
 Enlarged by fire, *ib.*
 Always in motion, *ib.*
 Its particles immutable, *ib.*
 Inflexible, 445
 Incompressible, *ib.*
 Its simplicity, 446
 Whence held the seminal principle of all things, 446 & n
 Of the mosaic creation, what, 446 n
 Its mildness, 447
 Warm water, an excellent anodyne, 448
 Is a solvent, 448, 449
 The proportion requisite to dissolve salts, 450, 451
 Dissolves not all metallic salts, 452
 Dissolves alcohol and fermented oils, 452, 453
 Saturated with salt, dissolves not alcohol, 452
 Dissolves saponaceous bodies, 453, 516
 Attenuated oils, *ib. ib.*
 Air, 454
 Saline bodies, 516, 517
 Terrestrial bodies, 454
 Even gold, *ib.*
 Not an universal solvent, *ib.*
 Insinuates into the pores of bodies, *ib.*
 Increases the weight and bulk of bodies, 455
 Concretes with saline bodies, *ib.*
 With sulphur, 455, 456
 With terrestrial bodies, 456
 With the solid parts of animals, 456, 457
 With oils and alcohol, 457
 The vehicle of nutritious particles, 136 n, 457, 458, 466
 Metallic water, what, 457
 Repels unctuous bodies, 458
 Repelled by solids, *ib.*
 Kinds thereof, *ib.*
 The universal nutriment, 447
 The purest, how obtainable, 460, 461, 462
 Marks of pure distilled water, 461, 462
 A cement, in sticking the parts of bodies together, 457
 Diffused through several bodies, *ib.*
 Constitutes a large part of the aliment of animals and vegetables, *ib.*
 Why called the universal wine, 458
 Preserved by spirit of vitriol, 459
 Putrefied, recovered by boiling, *ib.*
 Growing sweet again after putrefaction, 463 & n
 Considerably different in weight, 464, 465
 Its effects on the body, 466
 On vegetables, *ib.*
 Its use universal, *ib.*
- The grand instrument of fermentation and putrefaction, 467
 Its hot vapour very powerful, 467, 468
 Expanded by freezing, 468, 469 & n
 Contains something more subtile than air, 470
 Its waves, what, and how produced, *ib.*
 Whether convertible into earth, 471 & n
 Consider'd as a menstruum, 512, 513, 514
 Floating in the air may act as a menstruum, 520
 The vehicle of earth, 127 n
 Whether an insipid salt, 134 n
 Whether the nutriment of plants, 136 n
 Why it quenches fire, 289
 Why it prevents tin from melting, *ib.*
 It heightens the force of fire, 303
 Boiling, its rarification, 235
 Odoriferous and medicinal, how and from what vegetables best procured, 9 p, 12 p
 How preserved, 11 p
 Not pure, 9, 10 p
 How distilled vulgarly, 43, 44 p
 How from fermented vegetables, 48—55 p
 Their virtues, excellence, and uses, 48—51 p
 How improved by cohobation, 48 p
 Whence their taste and scent, 47 p
 How obtainable to best advantage, 9 p
 Their uses, 9—11 p
 Vomitive, whence, 45 p
Water-Poife, that of Dr. Hook, 440 n
Waves of Water, what, 470
Wax, what, 97 p
 How procured, 140 n
 How analysed, 98 p
 A kind of camphire, *ib.*
 Peculiarities of its oil and butter, 98, 99 p
Weight of Bodies corresponds to their reality, 101 n
 Relative, uncertain, 219
Winds, the great necessity thereof, 441
 Their effects on the air, 418
Wines, what, and whence procurable, 106 p, 114 p, 198, 199 p
 Their physical properties, 114—117 p
 The process in making them, 112, 113 p
 How made from meal and malt, 120, 121 p
 How made strong by standing on the lees, 114 p
 Retain not the taste of the subjects, whence they were made, 115 p
 What they contain, 116 p
 When most disposed to fret in the cask, 117 p
 How to be treated for distillation, 118 p
 Afford different liquors at different times of the distillation, 119 p
 How made into vinegar, 120—125 p

Wood,

I N D E X.

<i>Wood</i> , whence its durability, corruption, &c.					
Subject to two kinds of rottenness,	74 p	Y	<i>EAST</i> , what,	Y.	112, 113 p
How affected by the worm,	ib.		<i>Yolk</i> . See <i>Eggs</i> .		
How affected by time,	ib.			Z.	
Which best to distill for oil,	ib.	Z	<i>Affer</i> , what,		116 n
The least oily, the lightest,	ib.		<i>Zink</i> , what,		133 & n
<i>Wounds</i> , how healed to advantage,	96 p		Gives a gold colour to copper,		93 n
Without suppuration or cicatrix,	ib.		Purifies tin,		133 n
<i>Worms</i> , remedies against them,	81 p. 102 p.		<i>Zeximus Panopolitanus</i> , his history and writings,		7 & n
	225 p. 264 p. 278 p. 307 p		<i>Zythum</i> , what,		199 n
<i>Wormwood-Water</i> , its virtue,	49 p				

T H E E N D.



INDEX

Y
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z

THE END

